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ABSTRACT

This dissertation examines development of children's skills at map using and free-recall map sketching, with particular emphasis on map reasoning, competence in cartographic language, and performance in cartographic language. Cartographic language (the broad range of line, point, and area signs and map elements) is interpreted as the means by which a cartographer encodes a message on a map as well as the means which a map user employs to decode the map. The examination derived information from two sources--a review of literature and a research study involving concrete levels of map reasoning among approximately 600 students between the ages of eight and 14 in three public schools in Queensland, Australia. The document is presented in five chapters. Chapter I introduces the study, states objectives, defines key vocabulary terms and concepts, and presents background information on maps as graphic means of transmitting information. Chapter II reviews literature on cartographic language and communication. Chapter III explains the design of the study, characterizes the sample group, and discusses types of statistical analysis used to measure student competence and performance. Chapter IV presents data from the study. Chapter V presents findings, conclusions, and implications. Findings indicated that (1) children aged 13 and 14 were better able to interpret map language, perform map lettering, and to understand and reproduce maps than children aged eight through 12: (2) children are competent in identifying cartographic signs at an earlier age than they can comprehend these signs: (3) children's attitudes towards maps don't particularly influence their abilities to interpret or reproduce maps: and (4) many factors influence map competence and performance, including verbal and nonverbal ability and spatial ability. The conclusion is that individual differences continue to exist among children at all age and grade levels regarding map skills, but that children become progressively more competent at map skills as they are exposed to map work in the classroom. (DB)

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DEVELOPMENT OF COMPETENCE AND PERFORMANCE IN CARTOGRAPHIC LANGUAGE BY CHILDREN AT THE CONCRETE LEVEL OF MAP-REASONING

U.S. DEPARTMENT OF HEALTH,
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A THESIS

Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the Department of Education at the University of Queensland.

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ABSTRACT

This is a study based on semiology (the science of signs). The focus is on the map user in the cartographic communication process. The map users are children at the concrete level of map-reasoning. This study examines their development of competence and performance in cartographic language. It is also concerned with factors which influence : (a) the children's map-reasoning, (b) their competence in cartographic language; and (c) their performance in cartographic language.

The theoretical base of this study was derived from research into the cartographic communication process. This base permitted a systematic analysis of the two key participants in cartographic communication - the cartographer and the map user. For this study, cartographic language is defined as including the broad range of line, point and area signs presented in qualitative and quantitative forms; alphanumeric signs; and standard elements. Thus, cartographic language is the means by which the cartographer encodes a message on a map which the map user decodes.

The Salomon-Feldman map-reading test was used to classify Queensland children at the concrete level of map-reasoning. Children aged from eight to fourteen years were chosen for this study. Their development of cartographic language was investigated from the two viewpoints of competence and performance. Competence in cartographic language includes the processes of identification (knowing the look) and comprehension (understanding the meaning and the ability to make inferences) of cartographic signs. Performance in cartographic language

is the ability to use signs successfully in drawing maps.

Cartographic signs may be distributed along a continuum based on the distance between sign and referent. Cartographic signals which are virtual duplications of the referent from an orthogonal view are located at the most realistic end of this continuum. Arbitrary symbols are located at the abstract end of this continuum because of the lack of any resemblance between the sign and its referent. Pictorial symbols are located midway along the continuum.

A review of relevant research indicated a variety of factors which influence the map user in the cartographic communication process. The factors chosen for consideration in this study are:

a) map design variables - colour in cartographic signs, map generalisation and map lettering, and

b) map user variables - age, map-reading ability, home environment, previous experience with maps, understanding of the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence and spatial ability. (The children's competence was also included as an influence on their performance in cartographic language).

These factors are considered as influences on:

a) the children's level of map-reasoning,

b) their competence in cartographic language, and

c) their performance in cartographic language.

The research design utilised randomised blocks. The criterion reference - the Salomon-Feldman map-reasoning level - was used to create four blocks each containing seventy-five children. The data were analysed statistically using multivariate analysis of variance, discriminant analysis, univariate analysis of variance, multiple classification analysis and multiple regression analysis. Children's perceptions were analysed to determine their subjective views. These analyses were used to test eight hypotheses concerning the children's development of competence and performance in cartographic language, the factors which influence their level of map-reasoning, and their competence and performance in cartographic language.

This study concluded that for children at the concrete level of map-reasoning there is a significant development both in their competence and performance in cartographic language. The children do not identify or comprehend all types of cartographic signs equally well, a conclusion based on their competence scores. As expected,the children are competent in identifying cartographic signs at an earlier age than they can comprehend these signs. All of the selected map design and map user factors except children's attitudes to maps proved significantly influential in at least two of the three independent variables - map-reasoning, competence in cartographic language, and performance in cartographic language.

The study has significance for the following reasons:

1. It establishes the viability of the semiotic approach to the analysis of children's development of cartographic language.

2. It indicates the significant nature of the development in competence and performance in cartographic language by children at the concrete level of map-reasoning.

3. It establishes a range of map design and map user factors which influence significantly children's map-reasoning, competence and performance in cartographic language.

4. It suggests a range of curriculum and classroom implications which could be used to enhance the development of children's competence and performance in cartographic language in primary and secondary schools.

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CHAPTER ONE INTRODUCTION TO THE STUDY.

The purposes of this study are to investigate the development of competence and performance in cartographic language for children at the concrete level of map-reasoning and to determine which factors influence this development.

The objectives are:

1. To investigate the viability of the semiotic viewpoint which emphasises the science of signs, as an approach to analysing children's development of cartographic language.

2. To investigate the role of the map user in the cartographic communication process.

3. To determine whether there is evidence of development in competence and performance in cartographic language for children at the concrete level of map-reasoning.

4. To determine which factors influence children's map-reasoning, competence and performance in cartographic language ,via a number of tasks, including psychophysical studies. These factors will emphasise map user attributes and potentially influential map design characteristics.

Background to the problem.

Maps are graphic means of transmitting information. More precisely, they are the representations of spatial arrangements of objects drawn at a reduced scale from an orthogonal view on plane surfaces. Their distinctiveness is that they are graphic presentations of signs structured similarly to the spatial arrangement of phenomena represented - signs which have no fixed meanings and which are presented in no particular sequence. Maps possess key elements such as arrangement, proportion, orthogonal view and language/symbolisation.

Maps are one key form of graphic communication which is seen by Balchin and Coleman (1965) as one of the four complementary modes of communication (along with numeracy, literacy and articulacy). Specifically, they are the means by which information is transmitted in the cartographic communication process. Researchers such as Balogun (1978), Bosowski (1975), Kolacny (1969), Muehrcke (1969), Ratajski (1973) and Robinson and Petchenik (1976) have highlighted the systematic approach to the transmission of cartographic information - an approach which spotlights the key roles in the cartographic communication process (the cartographer and the map user). Since cartographic language is the means by which information is encoded on a map by the cartographer and decoded from the map by the map user, it plays a vital role in the cartographic communication process. Both cartographer and map user must be competent in cartographic language for the successful transmission of cartographic messages.

Cartographic language - the signs used on maps - has been shown by researchers such as Arnberger (1974), Langer (1951), Polanyi (1959) and Robinson and Petchenik (1976) to be quite different from language based on words. The grounds for this conclusion lie in the presentational nature of maps (i.e. they present all of their information simultaneously), the absence of a syntax, the opaqueness of the signs (i.e. the signs attract attention to themselves rather than to their referents) and the lack of fixed meanings for each cartographic sign.

Cartographic language is characterised by a broad range of line, point, area and alphanumeric signs presented in qualitative and quantitative forms. These signs are based on graphic principles such as those suggested by Chao (1968) and Ratajski (1971). Not all of them have been standardised internationally. This is especially so for thematic signs. However, there is sufficient standardisation of cartographic signs for cartographic language to be a reality.

A convenient means for analysing cartographic language is the use of semiology - the science of signs. The semiotic viewpoint recognises three overlapping divisions - syntactics, semantics and pragmatics. Syntactics, the rules for the internal structure of a cartographic system of signs, have been postulated by researchers such as Ratajski (1971). The semantics of cartographic signs concern the meaning of the signs and the relationship between signs and the concepts they represent. Psychophysical studies by Clark (1959), Crawford (1971), Dahlberg (1967), Ekman and Junge (1961), Flannery (1956 and 1971), Jenks and Capsell (1971), Jenks and Knos (1961), Kimmerling (1975) and Meihofer (1969) investigated the relationship between sign and meaning generally via thematic maps. These studies were artificial since they focused on the appearance of individual signs. International standardisation of cartographic signs has been achieved for topographic signs whereas the research on thematic signs is moving towards standardised discrimination of class intervals of signs and discrimination of economic cartographic signs.

Pragmatics, the relation of cartographic signs to their users, has become popular with the acceptance of the systematic approach to cartographic communication. Previous research in this domain has stressed the role of the cartographer as the encoder of cartographic signs. Recently, research studies by Bartz (1965 and 1967) and Bosowski (1975) have highlighted the role of the map user in the cartographic communication process. Very little thorough research has been undertaken to investigate the contributions of a broad range of factors on the map user in the cartographic communication process.

Much of the past research into maps and children such as that by Askov and Kamm (1974), Brown, Bowyer, Edwards, Giffard and Honeybone (1959), Hanna, Sabaroff, Davies and Farrar (1966), Kohn (1953), Sabaroff (1961) and Warman (1959), has concentrated on the broad range of map skills children develop without seeking to understand how the development of these skills occurs. Some studies, such as those by Cobb and Stoltman (1973), Miller (1967), Towler (1971) and Towler and Nelson (1967), have investigated individual aspects of children's map-skill development. The signs used on maps are mentioned in some of these studies, but there is a lack of substantiated research on children's development of understanding of these signs as well as very limited comment on the range of signs common to maps which children use. Most of the statements concerning the range of cartographic signs are made as clinical statements in journals which the average teacher is unlikely to read. Therefore, few teachers are aware of the breadth of signs used commonly on classroom maps.

The literature available concerning the development of children's understanding of the language used on maps is limited. Studies such as those by Blaut and Stea (1971) and Dale (1971) consider a limited age range of children and do not undertake a systematic analysis of the children's understanding of cartographic signs. Studies by Harris (1972) and Thake (1977) do consider some aspects of children's development of understanding of cartographic signs, but still not in a systematic manner.

Therefore, allied fields of knowledge were investigated to explain what happens when children use the signs on maps. Communication theory, when adapted by researchers such as Joliffe (1974), Kolacny (1969) and Ratajski (1973), provided the basis for the cartographic communication process even though maps present information in a non-sequential manner and do not possess a precise alphabet of signs which occur in a predictable way.

Psycholinguistic research and studies of cognition provided insights into the development of children's understanding, the concept of distancing and the concepts of competence and performance. The Piagetian concepts of signals and symbols espoused by Furth (1968) provide a base for the continuum of types of signs on maps. They can be related to the concept of distancing between sign and referent as explained by Werner and Kaplan (1963). Therefore, the signs which are most like their referents may be termed signals and those which are most unlike their referents are abstract symbols.

The cognitive aspects of understanding cartographic signs may be explained through the concept of knowing as proposed by Hanson (1958), Ryle (1949) and Soltis (1966). They differentiate between knowing what some object looks like and understanding or "successfully seeing" the object from its representation. This background gives rise to the concepts of identification (knowing the look of a sign) and comprehension (understanding the meaning of a sign) which are used in this study as the concepts underlying competence in cartographic language.

Psycholinguistic research, such as that by Cairns and Cairns (1976), Campbell and Wales (1970), Chomsky (1965), Hymes (1971) and Van der Geest (1975), provides the basis for the distinction between competence and performance in language. Their conclusions which are couched in de Saussure's concepts of la langue (structure) and la parole (residual variation) establish the concept of competence as knowledge of linguistic rules and relationships and the concept of performance as the individual's ability to use the signs meaningfully. The psycholinguistic researchers conclude that the individual requires a competence in the language plus a variety of cognitive, perceptual and motor skills, to perform successfully in the language. In the cartographic context, competence is the individual's understanding of cartographic signs as representations of spatial phenomena, while performance is the individual's ability to use cartographic signs to draw maps.

The role of the map user and nature of the factors which influence his map-reasoning ability, and also competence and performance in cartographic language have been researched previously in fragmented studies by various geographers, cognitive psychologists and sociologists. Balogun's cartographic information transferral system (1978) is one of the initial attempts to systematise these factors. The other major attempt to synthesise these factors is by Wood (1972). Geographical studies by Bartz (1967), Brown *et al*. (1959) and Carswell (1970), indicate the link between mapping ability and age. Cognitive studies by Heamon (1973), Piaget and Inhelder (1956), Rhys (1972) and Snyder and Feldman (1975), indicate the link between maps and spatial ability. Psychological studies by Dent (1972), Gibson (1970), Hochberg (1962) and Haber and Hershenson (1974) indicate the importance of visual perception in reading maps. Sociological studies by Blaut and Stea (1971), Dale (1971) and Vanselow (1973) indicate the importance of previous experience and socio-economic status with map performance by children.

The problems and their significance.

Three separate, but related, general problems were considered in this study. The problems that were formulated could be classified as:(1) questions that pertained to the development of competence in cartographic language for children at the concrete map-reasoning level, (2) questions that pertained to the development of performance in cartographic language for children at the concrete map-reasoning level, and (3) questions that pertained to the factors which influenced children's map-reasoning, competence and performance in cartographic language.

These problems are investigated to clarify the role of the map user in the cartographic communication process. They focus on the semantics and pragmatics of the semiotic approach to cartographic language. The investigations of the development of competence and performance in cartographic language for children at the concrete level of map-reasoning focus on the children's understanding of the relationship between different types of cartographic signs and their referents. This aspect of semantics is used to investigate the children's ability to identify and to comprehend a representative range of cartographic signs as a measure of their competence in cartographic language. Their ability to express cartographic signs via their performance in cartographic language in free-recall sketch maps also reflects semantics because it indicates the degree of distancing between sign and referent the children can incorporate in their signs.

The problem of pragmatics involves investigating a range of factors which the related literature indicates could influence the map user in the cartographic communication process. Since the roles of the cartographer and the map user cannot be isolated in a systematic study ,the factors considered in this study consist of a range of map design and map user variables. The map design variables are colour in cartographic signs, map generalisation and map lettering. The map user variables are chronological age, map-reading ability, home environment, previous experience with maps, understanding the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence,and spatial ability. Wherever possible, the children in the study are given the opportunity to express their perceptions of particular variables in a psychophysical investigation.

This study is significant because it is an unprecedented attempt to apply the semiotic approach to cartographic language in a research situation using a range of conventional map extracts rather than studying cartographic signs out of context. It is also significant because it makes an empirical analysis of the development of competence and performance in cartographic language by children at a concrete map-reasoning level. Finally, the study is significant because it analyses a variety of factors to determine which of them influences the map user's map-reasoning, competence in cartographic language and performance in cartographic language. All of these aspects combine to produce one of the most detailed investigations of the map user in the cartographic communication process so far attempted.

The study seeks answers to questions concerning:

(i) the competence and performance in cartographic language of children at the concrete level of map-reasoning;

(ii) the influence of a selection of map design and map user factors on these children's competence and performance in cartographic language, and their map-reasoning;

(iii) the children's perceptions of maps.

The specific questions that are pursued in the study were:

1. In relation to their competence in cartographic language, are there any differences between the mean performances of subjects in four concrete map-reasoning levels?

2. In relation to their performance in cartographic language, are there any differences between the mean performances of subjects in four concrete map-reasoning levels?

3. Is there a difference between the mean performances of subjects in four map-reasoning levels for three map design variables (map generalisation, colour and map lettering) and ten map user variables (age, map-reading

ability, home environment, previous experience with maps, understanding the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence and spatial ability)?

4. Is there a relationship between the observed performance on three map design variables - colour, map generalisation and map lettering - and performance for these same variables predicted from a combination of competence in cartographic language and map-reasoning level?

5. Is there a relationship between the observed performance on ten map user variables - age, map-reading ability, home environment, previous experience with maps, understanding the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence and spatial ability - and performance on these same variables predicted from a combination of competence in cartographic language and map-reasoning level?

6. Is there a relationship between the observed performance on three map design variables - colour, map generalisation and map lettering - and performance on these same variables predicted from a combination of performance in cartographic language and map-reasoning level?

7. Is there a relationship between the observed performance on eleven map user variables - age, competence in cartographic language, map-reading ability, home environment, previous experience with maps, understanding the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal

intelligence and spatial ability - and performance on these same variables predicted from a combination of performance in cartographic language and map-reasoning level?

8. (a) Is there any progression in the verbal definition of a map among children at the concrete level of map-reasoning?

(b) Do children at the concrete level of map-reasoning display any development in their understanding of cartographic information based on the positioning of names on maps?

(c) Do children at the concrete level of map-reasoning prefer colour in cartographic signs and is there any development in their preferences?

The theoretical bases of this study are elaborated in Chapter 2.

CHAPTER TWO REVIEW OF RELATED LITERATURE AND RESEARCH.

This study focuses on children's development of cartographic language. It highlights the individual's role in the cartographic communication process. The review of related literature and research consists of five parts (see Figure 1).

Part one presents an examination of the nature of maps and map information. It stresses that maps represent space and contain the structure of the represented space. A range of signs is used to represent space. Elements like orthogonal view and orientation may be identified on maps on the basis of their perception by users. A range of unique attributes of maps may be identified, e.g. a map is a presentational form of communication and its signs have location.

Part two states the location of maps in the domain of graphic communication. Graphic communication is defined as one of four complementary modes of communication along with verbal, oral and numeral modes. Maps are defined as forms of explicit knowledge. The distinctive differences between maps and verbal language are explained.

Part three deals with the process of cartographic communication. Maps are defined as the vehicles for this process. The cartographic communication process is a systematic approach to understanding the relationships between maps, their designers and their users. A range of models has been developed in the last decade to outline the mechanics of the cartographic communication process. Information theory was an historic inspiration in the development of the concept of cartographic communication, but it is largely irrelevant to an explanation of cartographic communication because of the nature of maps and the way meanings are ascribed to cartographic signs. The roles of the cartographer and the map user in the cartographic communication process are examined closely. The cartographer's role is to create maps to show what, how and where concerning selected areas. The cartographer should consider the ways map users perceive signs, the nature and organisation of signs, the process of generalisation, the use of colour and the placement of names on maps. The map user's role may be influenced by a range of attributes pertaining to the individual and his environment.

Part four presents an examination of cartographic language and its role as the means of communication between the cartographer and the map user. A semiotic approach to cartographic language which highlights syntactics (the rules of sign construction), semantics (the links between signs and their referents) and pragmatics (the relations between signs and their users) is explained. A continuum of cartographic signs is established from realistic cartographic signals through pictorial symbols to abstract symbols. This continuum is based on the concept of distance between a sign and its referent. The qualities of good symbols are elaborated and are related to maps. Cartographic signs are classified on a broad basis to consist of line, point and area signs presented by qualitative and quantitative means; alphanumeric signs (e.g. names) and standard elements (e.g. scale). Finally, the problem of the standardisation of cartographic signs is investigated. Considerable evidence of standardisation of cartographic signs is available, as are bases for the standardisation of thematic signs.

Part five reviews the individual's development of cartographic language. This development may be defined as the individual's development of fluency in competence (the ability to understand the meaning of cartographic signs) and performance (the ability to use cartographic signs successfully in map-making). Individuals develop competence in cartographic language via the processes of identification (knowing the look of a sign) and comprehension (understanding the meaning of a sign and being able to make inferences about it). Individuals develop their performance in cartographic language on the basis of their competence in cartographic language plus a range of individual characteristics.

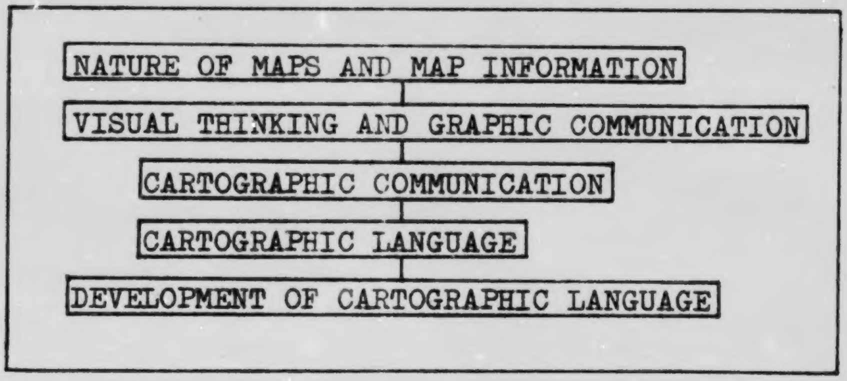

NATURE OF MAPS AND MAP INFORMATION
VISUAL THINKING AND GRAPHIC COMMUNICATION
CARTOGRAPHIC COMMUNICATION
CARTOGRAPHIC LANGUAGE
DEVELOPMENT OF CARTOGRAPHIC LANGUAGE

Fig. 1 STRUCTURE OF REVIEW OF RELATED LITERATURE AND RESEARCH

2.10 Nature of maps and map information.

Maps are visual instruments which transmit information about parts or the whole of the earth's surface. This visual technique representing a part of an area has been defined on many past occasions. Catling presents a synthesis of these definitions when he defines a map as

> "........a two-dimensional graphic representation of a selection of features or aspects of a surface, drawn at a reduced scale, and implying a vertically overhead viewpoint corresponding to that surface". (1978:2)

This definition stresses the representation of a spatial arrangement of objects on a reduced scale drawn from an orthogonal or plan viewpoint. It implies the use of signs to locate the main objects or groups of objects.

Maps are surrogates of space because they occupy space on a piece of paper, but they derive meaning and usefulness by representing other space, e.g. the local environment or a country (Robinson and Petchenik, 1976:4). Arnheim (1976:5) prefers to define them as graphic analogues (ikonic images) which show phenomana in their spatial context and share certain visual properties of the objects represented. The visual imagery generated by reading maps is acquired by observing certain cartographic signs and then imagining, based on one's experiences, what these signs mean. Hence names like Mt. Everest and Mekong River acquire meaning.

Korzybski extends this approach to maps by stating that maps are not the territory they represent, but they have similar structures to those of the territory represented. These similar structures are characterised by similar logical aspects and are maintained via proportional areas, retained shapes, proportions among distances and topological properties(1941:750). Therefore, the spatial relationship between London, Birmingham and Liverpool, will be reflected on an accurate map of England.

The concept of structure in maps also highlights understanding the totality of each map. Maps are art forms. The map reader is able to appreciate the totality of this art form from an understanding of the symbol system used in drawing the map and of the spatial correlation of the phenomena mapped. Geographers use two distinct operational systems - the logico-mathematical and the spatio-temporal - to articulate the space represented on maps (Robinson and Petchenik, 1976:114). These systems, which Harvey (1969:216) terms languages, were originally defined by Piaget to focus on logical operations dealing with individual objects considered as invariants and spatial operations linking or segregating objects in terms of proximity and distance (Piaget and Inhelder, 1956: 430-431).

Maps, along with most graphic images, have visual fields which consist of two-dimensional surfaces. The visual elements within this static graphic image may vary in :(a) location within the visual field,

(b) form,

(c) two dimensions and in

(d) colour. (Keates, 1973:3)

The elements within the map are arranged in the form of graphic symbols which form the basis of cartographic language. In transferring information from the earth's surface to a two- dimensional surface, an attempt is made to preserve four key properties:

i) true distance,
ii) true shape,
iii) true area, and
iv) true direction.

(McDermott, 1969:465)

Since no single map projection possesses all four properties at the one time, the map projection and the map scale chosen should be the ones that best preserve reality, whilst suiting the purpose of the map.

A range of cartographic signs composes a map. For both map designers and map users the key concern is with the information contained in each symbol. Keates has hypothesised that only a selection of the total information which describes it is shown by the map symbol (1972:169-170). The keys to whether a map designer can be fully conscious of what he is presenting in a map, lie in the abstraction and the generalisation of cartographic information. The abstraction of cartographic information occurs during the codification of this information in the form of signs. This process which cannot be standardised for all forms of cartographic information will be detailed in the section on cartographic language.

The process of generalisation holds the key to the selection of cartographic information for inclusion on particular maps. There should be sufficient information on each map to differentiate one group of features from another and where necessary, to indicate different sub-groups. Roads should be distinguishable from railways. Different classes of roads should be presented when there are many roads in the mapped area. Robinson and Sale (1969) have identified four elements of cartographic generalisation which are accomplished in creating each map:

i) simplification (the selection of phenomena, its modification and the elimination of detail, e.g. selection of the roads in an area as a network of lines),

ii) symbolisation (the coding of essential characteristics, comparative significance and relative position, e.g. developing a sequence of line signs to represent the variety of roads located on the map),

iii) classification (the ordering of phenomena studied by geographers, e.g. allocating the signs to the individual roads on the map), and

iv) induction (the application of the logical process inference, e.g. inferences as to the relative importance of particular roads).

The combination of these elements will vary with each map and will depend on the following controls:

i) the objective or the purpose of the map,

ii) the scale or the ratio of earth/map reduction (the smaller the scale the fewer the details),

iii) the graphic limits or the capabilities of the technology used to draw the map, and

iv) the quality of the data being mapped (Robinson and Sale, 1969:52).

The marvel of mapping according to Toulmin (1958:110-111) is that

> "......from a limited number of highly precise and well-chosen measurements and observations, one can produce a map from which can be read off an unlimited number of geographical facts of almost as great a precision."

Such a map is route-neutral in that it represents an area in a way which is indifferent as between starting points and destinations. Therefore, the map user can select his/her own starting point to read the map and can then analyse it in any desired order.

Shemyakin adds further insight into the nature of maps when he states that although a map presents the spatial relations of the earth's surface via the spatial relations of the elements of which it is compiled, the map does not represent a view of earth from above. This is because elements of conventionality (signs) appear and it possesses no perspective, i.e. cities observed from above are not usually circular in shape and objects on the Earth's surface overlap and overlay other objects (1962:238).

Maps are different from photographs. The signs on maps express ideas by representing them. They are the medium for the expression of these ideas. Photographs are meant to look like objects. Cartographic signs indicate common groupings whereas photographic representations do not. Map symbols are combinations of artificial devices (Alexander, 1967:14). These signs are naturally associated with their referents via

i) imitation, e.g. windmill,

ii) contiguity, e.g. oil derricks for oilfields, and

iii) association of two senses, e.g. grey/blue for cold deserts (Wood, 1968:57).

Some conventions exist on maps, e.g. north pointing to the top of the page. However, the signs on maps are not as standardised as for written language. Consequently, the map user usually requires a legend to interpret the map. Above all, the map user must be able to extract the required symbol or group of symbols from the map with maximum facility. Merriam (1965:10), in showing the differences between aerial photographs and symbolised maps, indicated that the progression from photo image to map form results in removing the sharper differentiations of individual photo images and making those in a given class appear more alike. This process involves two steps:

i) removal of individual tonal difference and

ii) uniform strengthening of symbol classes.

Merriam states that the misunderstanding which supposes that the photograph is as symbolised as the map arises because one discounts the interpretative skill of specialists to determine that unlike images belong to the same class. This view does not account for the realism of the signs on the photograph, e.g. plan views of trees, houses and rivers are observed on vertical aerial photographs. The relatively new orthophotomap which has all of the geometrical properties of a conventional map fits in between the variety of aerial photographs and the range of symbolised maps (Petrie, 1977:50). The use of stereo-plotting technology has removed the effects of camera tilt so that a photographic representation of an area presented to scale and arranged faithfully can be used by map readers. The signs on the orthophotomap are much more realistic than on the symbolised map. The orthophotomap does suffer from the absence of a legend for the complex array of cartographic signs presented on it. Despite the presentation of the total landscape of the area represented on the orthophotomap, it is the most realistic map form readily available to map users.

What then are the elements of a map? From a psychological viewpoint, Shemyakin (1962:239) identifies three groups of elements on a map:

i) mathematical bases (standard elements such as scale and direction),

ii) geographical figures (islands, continents and other geographical configurations), and

iii) conventional signs (both topographic and thematic).

A map is read on the basis of the perception of these elements.

Catling (1978:3-8) concludes that the map consists of eight elements - two structural elements (location and orientation), four designative elements (vertical overhead viewpoint, two-dimensional representation, scale and symbolism) and two content elements (content discrimination and additional information), all of which may be arranged into a structure (see Figure 2).

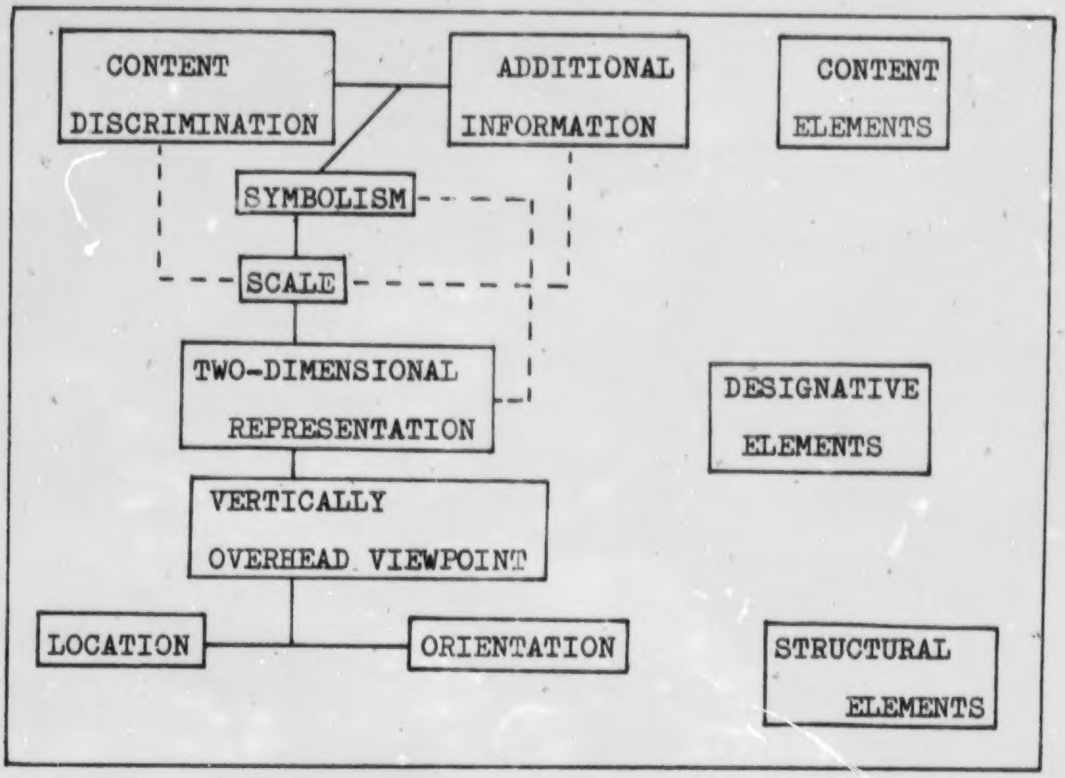

CONTENT DISCRIMINATION
ADDITIONAL INFORMATION
CONTENT ELEMENTS
SYMBOLISM
SCALE
TWO-DIMENSIONAL REPRESENTATION
DESIGNATIVE ELEMENTS
VERTICALLY OVERHEAD VIEWPOINT
LOCATION
ORIENTATION
STRUCTURAL ELEMENTS

Fig. 2. CATLING'S STRUCTURAL RELATIONSHIP OF MAP ELEMENTS.

The structural elements (i.e. location and orientation) are the referent basis of the map because they define the axis and reference system of the map. Such elements are not unique to the map as they are evident in photographs, graphs and diagrams. The designative elements (i.e. vertically overhead (orthogonal) viewpoint, two-dimensional representation, scale, and symbolism) distinguish the map from other graphic forms as they identify the viewpoint position, and representational problems that occur when representing a curved area on a flat surface. The projection adopted, the amount of generalisation necessary and the abstractness of the cartographic signs are typical of these problems. The content elements (i.e. content discrimination and additional information) indicate that the map designer must select cartographic information. They also indicate that maps are used to display relationships that are not readily identifiable at ground level or as a simple representation of an area.

Snyder and Feldman have presented a simpler structure of the elements of a map. They indicate that a map consists of:

i) arrangement (the distribution of objects in the same pattern as in the area being represented on the map),

ii) proportion (the drawing of signs to maintain the relative sizes of objects in the represented area),

iii) perspective (the drawing of signs to represent the orthogonal or plan view of the represented area), and

iv) symbolisation (the use of signs to represent the location and/or extent of phenomena in the represented area). (Snyder, Feldman and La Rossa, 1975:7)

The most encompassing summary of the distinctiveness of maps and their manner for portraying information was made by Robinson when he synthesised the conclusions of extensive research by Petchenik and himself (1977:73-74). Robinson stated that a map has six attributes which make it unique:

i) a presentational form of communication (Maps are simply a variety of marks/signs made on a plane surface. The marks and the concepts they encode, unlike spoken or written language, are displayed all at once and in no particular sequence.);

ii) map marks/signs are not carriers of fixed meanings (A black dot may be a town, 100 sheep, part of a political boundary or a railway station.),

iii) map marks/signs have location. (Each mark/sign is placed carefully on the map to indicate its spatial relation to all other marks/signs. Areas with a cattle-carrying capacity of ten beasts per hectare are located on the map in relation to the towns and beef roads.);

iv) map marks/signs are opaque (The map is treated as a whole out of which the map user constructs his own structures based on the nature of the graphic display and his geographical background. Words or speech unlike maps, are transparent because the reader or listener can absorb the concepts without paying a great deal of attention to actual words or sounds as objects.) (Polanyi, 1964:57);

v) the quality of image (Maps are space representing space. The creation of spatial images is inherent in creating maps and reading maps. Spatial imagery is necessary for spatial cognition since map designers and users must be able to imagine what objects look like from above before they can encode or decode map marks/signs. They must be able also to conceptualise the arrangement of objects in space.); and

vi) a quality of structure (each map represents a meaningful spatial relationship of geographical phenomena. The signs on the map are arranged in the same manner as the objects they represent are located on the earth's surface).

Summary. Maps represent space. They contain the structure of the represented space. Maps consist of a range of graphic signs which are organised to present a generalised view of the represented area. This presentation of information is route-neutral since maps do not possess a defined starting point for reading them. Structurally, maps consist of a collection of elements which may be arranged variously. Consequently, one may identify a group of unique attributes of maps.

2.20 Visual thinking and graphic communication.

The ability to use maps is not the same as the ability to use words or to speak. Guilford (1959:477-478) concluded that there are four kinds of intelligence: concrete intelligence using figural information, abstract intelligence using words (language), abstract intelligence using numbers (mathematics) and social intelligence which includes nonverbal aspects. Blonskiy (1935:23-200), in his research on memory development, concluded that the concept of memory was composed of four types : motor, emotional, pictorial and verbal memory, which are genetic stages of its development. Balchin and Coleman (1965) and Balchin (1972 and 1976) took Guilford's findings and derived four modes of communication : graphicacy, articulacy, numeracy and literacy. These are complementary modes of communication. Their optimum use depends on the learning situation. For example, a learner may describe the location of a town orally (articulacy), write a paragraph to describe the town's location (literacy), draw a map of the town's location (graphicacy) or compute the distances between the town and neighbouring urban areas (numeracy). The challenge is to use the best mode of communication for one's purpose. A solution to this challenge is advanced by Russian researchers Faraponova (1957, 1958), Lipkina (1958), Mal'tseva (1957, 1958) and Razmyslov (1958), who concluded that an individual's visual memory develops before his verbal memory because it is more concrete.

It has been argued that our education system is dominated by the skills of literacy and numeracy. A plea for greater exphasis on visual thinking forms an integral part of this argument (Sless, 1978:2). Graphicacy is a key element in visual thinking. Balchin put the case for graphicacy succinctly when he wrote:

> "Graphicacy aims at an accurate interpretation of the real world and is concerned with Euclidean precision measurement, representation and interpretation. It should be an integral part of the education of each individual to enable him fully to appreciate and understand his environment." (1976:38)

Maps, along with diagrams, photographs and other spatial documents are the tools of graphicacy, (Balchin, 1972:185). Fluency in visual expression, as with verbal expression, is derived from practical experience, knowledge and understanding of the language itself and of the principles guiding its effective use. Bowman indicates that visual language has four resources and capabilities peculiar to its own nature:

i) a vocabulary of form elements (Form derives from five basic elements - point, line, shape, colour and texture - which constitute the form vocabulary for graphic communication. Points show location, position or focus and are characterised by convergence of form or visual impact. Lines show direction, extension or movement. They may be used to describe a route or a boundary. Shape acts as a plane form to show contour, area, outline, edge or enclosure. Colour via its value or degree of lightness or darkness indicates differences through graduated tones. Texture shows variations in surface structure or pattern. The varying patterns of small particles "feel" different to the observer's eye.);

ii) a grammar of spatial organisation (Whatever its form, a figure exists on a plane surface. By adding a dimension of depth which can be created by the presence or absence of spatial cues, elements of the figures can be conceived as being located on the plane surface and behind it. Therefore, space organisation can be plane where figures appear flat both in structure and arrangement, multi-plane where a secondary plane is located behind the orginal plane and parallel to it (e.g. unequal line weights, distance association of recognisable forms or overlapping forms), and continuous where form is seen to extend inward from the plane to create an illusion of spatial mass (e.g. separation of forms in depth by colour value contrast and superimposition of closer forms on farther ones.);

iii) a volumetric perspective which is based on the principle that the apparent sizes of objects vary in direct proportion to their proximity to the eye

(Because maps are representations of objects viewed from above they lack any such perspective.) ; and

iv)a syntax for phrasing the image or the basic ways in which the visual image elements function to create an articulate visual statement. (The primary modes of visual interaction are relationship, differentiation and emphasis. Relationship, the ways in which form elements are brought into association with each other, may be achieved by spatial contiguity or arrangement of elements and by quantitative organisation of elements. Differentiation or the visual dissociation of elements may be achieved by differences in the quality of textural patterns and by physical differences in the structure of the basic forms. Emphasis or the domination of form elements of the figure may be achieved by the dominance of tones, physical dominance or sharpened textural quality).

(Bowman, 1968:9-27)

The distinctiveness of graphic modes of communication is enhanced by comparing visual and verbal communication. Visual images, the bases for visual symbols, address themselves to the same sense organs through which one obtains visual information about the objects they symbolise. Words, verbal symbols, receive definition by the association of a sensuous awareness with an oral or a visual symbol. While there are dictionary meanings for word symbols and there may be dictionary definitions for objects symbolised by lines and dots, there are no such definitions for the lines and the dots themselves.

This has led Ivins to conclude that:

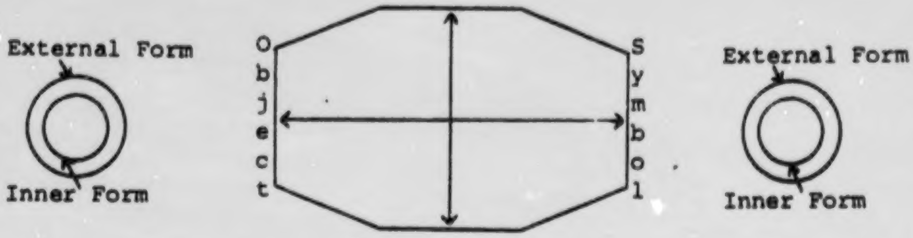
> "While both words and pictures are symbols, they are different in many ways of the greatest importance. So little are they equivalent to each other that if communication were confined to either alone, it would become very limited in its scope."
> (1953:158-159)

For Wendt (1962: 175-181) pictures are surrogates for experience (reality). Pictures are not symbols as words are symbols since a young child can recognise a photograph, but he or she may not be able to read. Pictures are a language in themselves. They range from absorbing realism to high levels of abstraction. Like words, every picture has a content of meaning partly intensional and partly extensional. Composition and light may be termed the grammar of photography. Pictures possess semantic dimensions since every photograph is an abstraction of an object or event. Wendt stresses the similarity between a map and a picture in that neither possesses a one-to-one correspondence between the elements of the picture and the elements of the event. Pictures, like maps, possess structures which are based on a configuration of symbols which permit interpretation, providing the user is competent in reading these symbols. Pictures are also multi-ordinal since they are interpreted on different levels of abstraction. The same may be said about maps which use signs of different levels of abstraction.

> "The basic error is to fail to realise that the meanings of pictures are not in the pictures, but rather in what we bring to them." (Wendt, 1962:183)

The futility of relating the structure of mapping with that of verbal communication is highlighted by adopting Langer's concepts of discursive and non-discursive symbols. Discursive symbols fit into a system where names and named relations or activities are placed side by side in an order which has no bearing to their arrangement in space (Langer, 1951:77). Non-discursive symbols, e.g. visual forms, are presentational because they present their components simultaneously (Langer, 1951:88). Langer (1951;89) uses a black-and-white photograph to show that words describing the photograph have fixed meanings and can be combined into composite symbols with new meaning. However, the grey tones that make up the photograph by themselves have no significance. Robinson and Petchenik (1976:52) conclude that maps are much more presentational than discursive. They possess no syntax; are more stylised than pictures (i.e. they contain legends) ; and they represent some characteristics of an area.

Cartographic signs can be distinguished from other kinds of presentational forms such as painting and photography on the basis of Langer's concept of pair-relations. Pair-relations focus on the relations between the object and the word, between the user and the word, or between the user and the object (Langer, 1951:58). Werner and Kaplan (1963:40-51) have used this concept to explain the concept of distancing in the symbolisation process. As Figure 3 indicates, they have extended the pair-relations to include the relation between the author of the message (the encoder) and the receiver of the message (the receiver). The lines, points and areas which constitute a map are signs which may contain shape, hue, value, intensity, extent or texture. These signs, unlike those in



(after Werner and Kaplan, 1963)

Fig. 3 DISTANCING IN THE DEVELOPMENT OF SYMBOLS.

painting or photography, can have verbal equivalents - a green symbol represents trees, a black square a building and a blue line a river. These verbal equivalents are located in the legend of a symbolic map.

Polanyi (1959:12) states that maps, like words and mathematical formulae, are forms of explicit knowledge which may be examined objectively. Understanding of these signs is achieved by using tacit knowledge, an unaviodable act of personal participation in our explicit knowledge of things. Map signs in the form of words cannot communicate an understanding in themselves.The transmitter of the message will always have to rely on the receiver for comprehension of the message. The reorganisation of information from new points of view, e.g. the construction of maps of an area, is a tacit process. Polanyi transposed Gestalt psychology into explicit and tacit knowledge. He developed the concepts of subsidiary awareness (knowledge of the particulars in terms of the whole) and focal awareness (knowledge of the particulars in themselves). Maps embody subsidiary awareness since they are not objects of attention in themselves, but pointers to the things they mean (Polanyi, 1959:30).

Polanyi's concept of transparency, whereby the meaning in words may be retained after the words have been forgotten, adds another dimension to the distinction between map signs and words (Polanyi, 1964:57). Words are transparent because one can recall the meaning of a message after the actual words have been read or uttered. Map signs, on the other hand, are opaque because they attract attention to themselves rather than to their referents. When most map users first encounter a particular map what they remember are the colours, lines, shapes and type. Very experienced map users may inject some meaning into the map at first use. The more the user becomes competent in cartographic language the greater the opportunity for the map to become transparent. In most cases, the map display remains opaque (Robinson and Petchenik, 1976:60).

In verbal language the user is required to understand the grammar before using it successfully. For this, the user must understand the construction of sentences and other combinations of words (its syntax), develop a vocabulary (words of fixed meaning) and appreciate the projective technique whereby sensory expressions are transformed into language (Langer, 1951:94). Robinson and Petchenik (1976:54-56) have compared maps with verbal language and have concluded that in maps the consequential spatial arrangement symbolised via imagery constitutes the equivalent of the projective technique. The vocabulary of verbal language does not correspond with anything on maps because the maps' signs do not possess fixed meanings. The syntax of verbal language also does not equate to anything on maps because the order of meaningful components is prescribed by their arrangement in space.

Therefore, cartographic information is unsurpassed as a means of representing spatial information for the following reasons:

i) verbal representation, in which words follow each other, can present a sequence of ideas but not regional co-existence of information;

ii) numerical information offers only the possibility to give the map reference via co-ordinates;

iii) diagrammatic representation represents single objects or groups of objects without any relation to space in an isolated way; and

iv) pictorial representation lacks the clear attachment of objects to terms, their delimitation and cartometric measurement in an accurate manner (Arnberger, 1974:19).

Summary. Maps are vehicles for graphic communication. Graphic communication is one of the four complementary modes of communication, along with verbal,oral and numerical modes. Maps are explicit forms of knowledge. Their presentational form is the basis for the fundamental differences between maps and verbal language.

2.30 Cartographic communication.

> "The idea of the map as a passive graphic illustration of the spatial relations on the surface of the Earth seems to be more and more

> out-of-date. The praxiological approach to the map as an instrument of activities, as a working tool, has been recently winning more and more ground. This tool emits a load of information thus affecting the user in some predetermined direction but, on the other hand, it is itself submitted to analytical and synthetic operations affording eventually new information."
> (Ratajski, 1974:140)

This statement introduces the role of maps in the process of communication. According to Koeman (1971: 170) if maps are defined as vehicles for communicating cartographic signs, then , many of the problems of accuracy, function and truth of maps would be solved. Jenks (1970;175) concurs by stating that a map is

> "......a communication channel connecting the author through time and space with a reader to whom the map outputs concepts as it is looked at and perceived."

A map should indicate more about reality than can be perceived by one's senses. How well this is achieved depends on the cartographer's ability to obtain full information about reality and to generalise and transform it into cartographic information. Greatest efficiency in maps will be acquired when they :

i) satisfy the consumer's needs and interests,
ii) are easily readable and understandable,
iii) are attractive, and
iv) possess an overall emotive, as well as rational, effect.

(Kolacny, 1969:47)

In addition, Ratajski (1973:217) identifies three key factors in the efficiency of maps to transmit information:

i) the development of the sciences which provide increased information,

ii) the development of technology, and

iii) the general intellectual level of map users.

2.31 The cartographic communication system.

An understanding of the cartographic communication process is acquired via a systems approach which recognises the distinctive roles of the map author and the map user and the relationship between them. The basis for such an understanding is a general communication system such as the one devised by Johnson and Klare (1961) (Figure 4). It is characterised by a set of linkages which can be used to model any type of information flow. The message is transmitted in the form of signals from a source to a destination through a communication channel. Receipt of the message is conditioned by the amount of noise (unwanted signals) present.

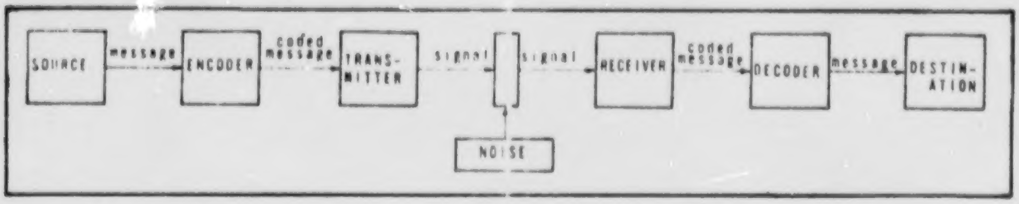


Fig. 4 MODEL OF A GENERALISED COMMUNICATION SYSTEM

One can identify five key factors in adapting this model to fit the cartographic communication process:

i) the map author,

ii) the map user,

iii) the intended message of the map,

iv) the mapping technique, and

v) the message received by the map user.

The map author (the originator of cartographic messages) and the map user (the receiver of cartographic messages) are the two key participants in the cartographic communication process. Map authors need not be cartographic draftsmen. They are the initiators of cartographic information (Monmonier, 1977:9). Researchers including Kolacny (1969), Muehrcke (1972), Ratajski (1973) and Robinson and Petchenik (1976) use the term "cartographer" to include both the originator of cartographic ideas and the presentation of these ideas in a graphic map form. For the purposes of this study the term "cartographer" will be used in the broad sense just defined. Another term, "map designer", is often used along with "map author" and "cartographer". Keates' definition of map design as

> ".....the graphic presentation of information contained in the map"

indicates that the map designer's role is that of a draughtsman and is much narrower than the broad role of a cartographer (Keates, 1973:29). It is the cartographer's ultimate responsibility to minimise the discrepancy between the message intended and the one received (Muehrcke, 1973:190). If the cartographer is to achieve this, he must:

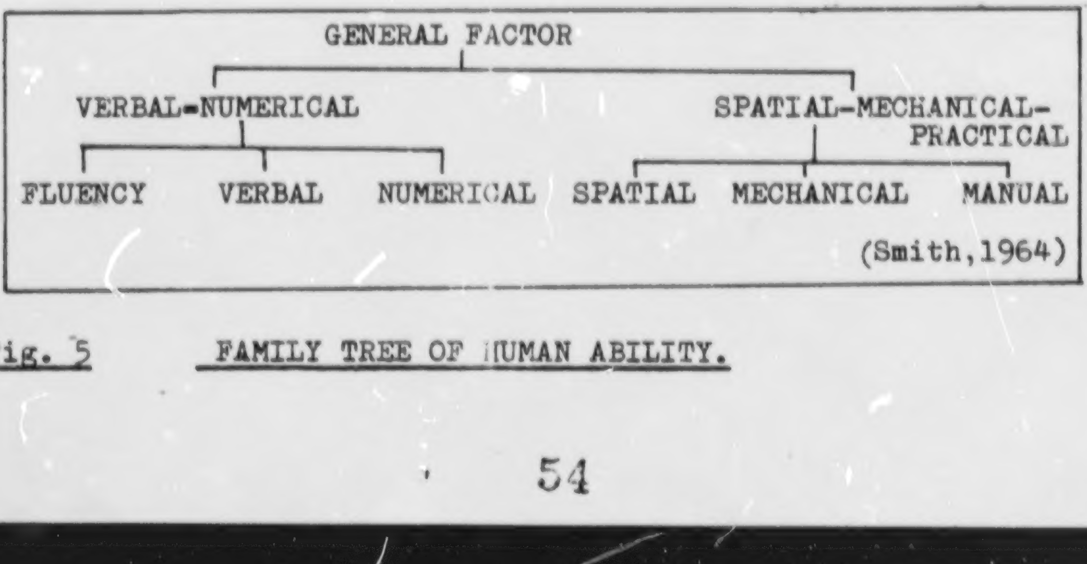
i) know the needs, interests and tasks of map users,
ii) be conversant with their levels of knowledge, ability and skill,
iii) be aware of their methods in working with maps, and
iv) appreciate the environmental conditions in which the maps are used. (Kolacny, 1969:47)

The map user is the least controllable aspect of cartographic information.

He brings to the communication process varying intellectual abilities, environmental influences and experiences which can cause great difficulty for the cartographer seeking to communicate an accurate cartographic message. Smith (1964:25) viewed human abilities as a family tree (Fig. 5) in which spatial ability was located on the second branch. These abilities of sensing and retaining geometrical forms and of manipulating spatial relationships mentally may provide a useful guide in predicting map users potential achievements in map-reading. However, it is difficult to know what the map user wants in maps. As Wood reiterates:

> "......his reactions to maps, even of good design, are influenced by so many factors that, no matter how carefully the first half of the communication process is structured the transmission of information often fails." (Wood, 1972:130)

Children's difficulties in reading maps have been reported in a range of applied research. Bartz (1965) reported children's difficulties with the conventions and symbols on maps. Sandford (1972) reported that English secondary students did not understand cartographic generalisation. Blaut and Stea (1971) concluded that higher-social standing aided map-reading ability in pre-school children. Dale (1971) found that local experience improved map-reading performance.



(Smith, 1964)

Fig. 5 FAMILY TREE OF HUMAN ABILITY.

The use of the term "map user" has been dabated by theorists. Most agree with its use as the receiver of map information, e.g. Kolacny (1969), and Ratajski (1973). Robinson and Petchenik (1976:20) opt for the term "percipient" because they see a percipient as one who obtains information about the milieu by looking at a map, whilst the map user is one who seeks specific information from a map. They contend that the percipient is adding to his spatial knowledge whilst the map user is not. For this study the term "map user" will be retained in its broad sense.

The process of transforming raw cartographic information into messages is achieved by creating maps. Maps are the medium or channel for cartographic communication. Cartographic language is the means by which the cartographer encodes information on a map and the means by which the map user decodes the information to receive the message. The system of cartographic signs acting in the form of a map is the language of cartographic transmission (Aslanikashvili, 1967:13-14). Bosowski notes the crucial nature of cartographic language:

> "Cartographic language is the means by which the map author is able to express a message as a graphic artifact. The extent to which a map user can accurately extract the map author's message from the map depends on the map user's ability to understand cartographic language."
> (Bosowski, 1975:20-21)

The nature of cartographic language with its variety of conventional and thematic signs will be elaborated later in this chapter.

The mapping technique used by the cartographer to generalise, classify and symbolise information influences how he encodes his cartographic message and the possibility of the map user decoding it. Hitt, Schutz, Christner, Ray and Coffey (1961) proposed a comprehensive table of considerations necessary to produce clear, accurate cartographic displays (Table 1). The range of considerations in regard to format, density, number of categories, coding , and rate of change, indicates the complexity of the encoding problem.

How map users decode the relevant cartographic message has been the subject of a variety of research. McCleary (1970: 191-192) concluded that there were three stages displayed by users in reading thematic maps:

i) scanning the map,

ii) visual organisation supplemented by fixations concentrated on small areas of the image ,and

iii) search or analysis to correlate maps with others.

Bartz (1970a), in a study of children searching map type, found that factors such as the figure-ground relationship, location on the page, contrast and the typographic environment were more important than the typography of a particular word. These studies indicate the need to know more about the link between visual perception and map design.

A cartographic communication system such as that proposed by Joliffe (1975:176) adapts the general communication system of Johnson and Klare and indicates that cartographic communication often does not function smoothly because breakdowns can occur (Figure 6).

Table 1 PROBLEM AREAS FOR CARTOGRAPHIC DISPLAYS.

Display Parameters	Variables
A. Format	1. Degree of pictorial reality
	2. Area covered
	3. Use of texture
	4. Use of colour
	5. Use of elevation
	6. Mosaic or single map
	7. Black on white versus white on black
	8. Size of display
	9. Ambient/display lighting ratio
	10. Scale
B. Density	1. Amount of detail of geographic nature
	2. Number of names
	3. Number of symbols
C. Number of Categories	1. Types of information
	2. How many types of symbols
D. Coding Dimensions	1. How are categories coded
	2. Use of coloured symbols
	3. What dimensions (e.g. size, shape) for each category
	4. Families of symbols
	5. Degree of reality in code-association characteristics
E. Rate of Change	1. Number of different maps per unit time
	2. Rate of updating symbols on maps.

(after Hitt, Schutz, Christner, Ray and Coffey, 1961)

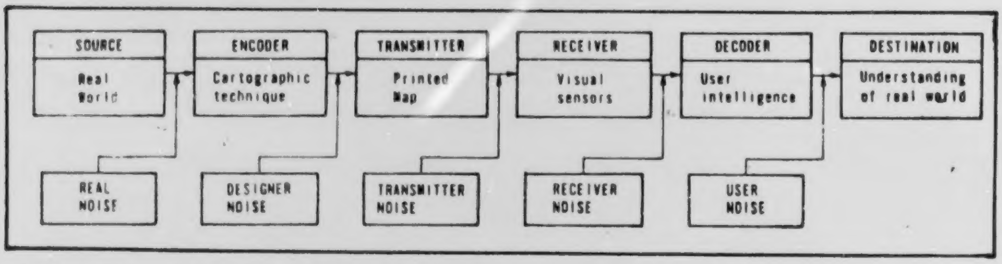

SOURCE
Real World
ENCODER
Cartographic technique
TRANSMITTER
Printed Map
RECEIVER
Visual sensors
DECODER
User intelligence
DESTINATION
Understanding of real world
REAL NOISE
DESIGNER NOISE
TRANSMITTER NOISE
RECEIVER NOISE
USER NOISE

Fig. 6 JOLIFFE'S CARTOGRAPHIC COMMUNICATION SYSTEM.

Researchers have advanced various reasons for the occurrence of such breakdowns. Henderson (1976:175) concluded that the main functions in cartographic communication loss are the cartographer's ignorance of map design, cartographic techniques, visual perception and the map user's psychological state. Roberts (1977: 101-102) suggested that these breakdowns occur because of under-educated cartographers, the cartographer's lack of awareness of the communication process, the difficulty in making a single map to suit every map user, the visual effect of the map as the user perceives and interprets it, and the ability and training of the map user. The necessity for improved educational techniques in map work and informing people about the principles underlying generalisation and symbolism in cartography should be highlighted. Olson (1975) concluded that user training can produce improvements in cartographic communication. She also found that design modification produced improvements in cartographic communication. However, the two approaches are complementary because the improvements are different in nature: experience and training assisted improvement with a greater dispersion of estimates in thematic maps whilst rescaling of symbols produced improvement via design modification.

One approach to these breakdowns is to use the concept of noise or unwanted signals as Joliffe does in his model (Figure 6). Noise may be positive or negative. It occurs at all major interfaces in the cartographic communication process. This concept of noise differs from the strict scientific definition as typified by Shannon and Weaver (1949) and Shannon (1948) by its lack of quantification. The concepts of real world designer, transmitter, receiver and user noise are descriptive concepts. Joliffe makes the following observations about each type of noise.

i) Real noise is that part of the signal which is considered irrelevant to the purpose of the map, e.g. unnecessary names of places. This can be reduced by careful selection by the cartographer.

ii) Designer noise includes the effects of decisions concerning lettering, layout, symbolisation, class and interval selection, colour and so on. Psychological considerations relating to visual perception need to be applied here to minimise designer noise.

iii) Transmitter noise relates to the quality of map printing techniques and colour control. Noise of this type can only be minimised by improving the quality of the technology for reproducing maps and upgrading the skills of the technicial operators.

iv) Receiver noise derives from the visual sensors of the map user. This type of noise is influenced by visual acuity, colour vision, familiarity with signals presented and visual perception.

v) User noise derives from the personality and intellect of the map user. It reflects such things as intelligence, experience and previous knowledge of maps. The cartographer has no control over this type of noise. (Joliffe, 1974:176)

2.32 Models of cartographic communication.

A variety of models has been developed by theorists since communications theory and systems theory were applied to cartography. The various models have been developed by theorists struggling to determine whether the cartographic communication model should emphasise the cartographer, the map, the map user, the information transferred between cartographer and map user, the cartographic process of transferral, or the factors affecting the information. Even though they have encompassed the cartographic communication system, all of the existing models except one have concentrated on one aspect of cartographic communication at a time.

Kolacny (1969:48-49) produced a comprehensive model (Figure 7) which highlighted the factors acting in the process of communication of cartographic information. He identified seven important factors acting in the process of communication of cartographic information: (i) reality as seen by the cartographer (U_1), (ii) the person representing reality-the cartographer (S_1), (iii) cartographic language as a system of map symbols and rules for their use (L), (iv) the product of cartography -

the map (M), (v) the person using the map - the map user (S_2), (vi) reality as seen by the map user (U_2), and (vii) cartographic information (I_c). The complex process of operations occurring during cartographic communication have been simplified to seven by Kolacny:

i) selective observation of reality by direct field observation or from existing maps,

ii) the effect of selective information which produces a multi-dimensional concept of reality,

iii) the transformation of the multi-dimensional concept of reality into a two-dimensional form (cartographic information),

iv) the development of a map of the cartographic information by the use of map symbols,

v) the informative effect of the map on the map user to transform his opinion of reality,

vi) the creation in the map user's mind of the cartographer's multi-dimensional concept of reality, and

vii) the map user's utilisation of his newly-acquired cartographic information.

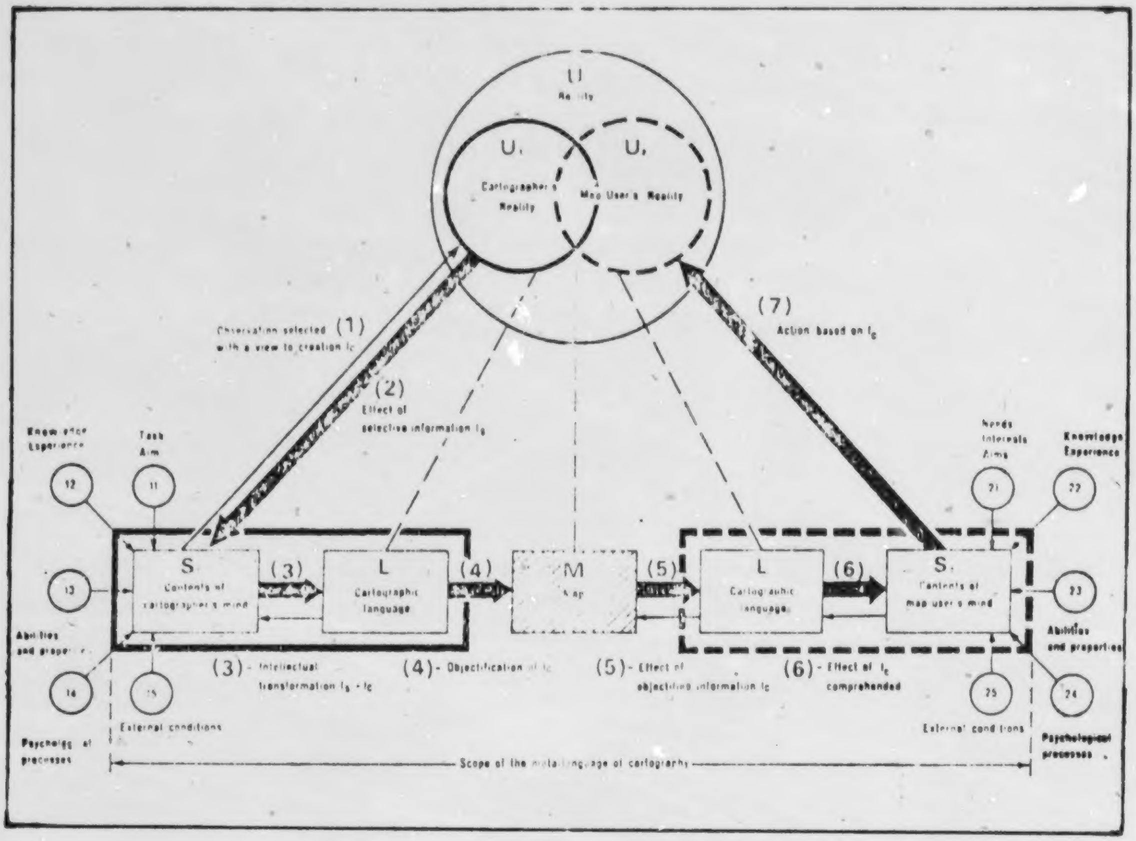

U
Reality
U₁
Cartographer's Reality
U₂
Map User's Reality
Observation selected (1)
with a view to creation Ic
(2)
Effect of
selective information Is
(7)
Action based on Ic
Knowledge Experience
Task Aim
12
11
13
14
15
Abilities and properties
Psychological processes
External conditions
S
Contents of cartographer's mind
(3)
L
Cartographic language
(4)
M
Map
(5)
L
Cartographic language
(6)
S₂
Contents of map user's mind
Needs Interests Aims
Knowledge Experience
21
22
23
24
25
Abilities and properties
External conditions
Psychological processes
(3) - Intellectual transformation Is - Ic
(4) - Objectification of Ic
(5) - Effect of objectifying information Ic
(6) - Effect of Ic comprehended
Scope of the metalanguage of cartography

Fig. 7 KOLACNY'S MODEL OF THE COMMUNICATION OF CARTOGRAPHIC INFORMATION

Ratajski's model (1973:218-219) based on his theory of cartology and on the models of Kolacny, Wojcik (1969), and Board's general communication model (1967), is one of cartographic transmission. It discusses the processes involved in transferring a message from reality to the cartographer to the map user (Figure 8). Ratajski identifies four stages in the transmission process:

i) direct recognition by the cartographer of reality (the source of chorological information) which involves the selection of the essence of the cartographic information;

ii) creation of the cartographic message as a map which involves the process of selection and coding in a system of symbols as well as perceiving the technical processes required to construct the map;

iii) the map user's receipt of the cartographic information by the process of map emission;and

iv) the map user's creation through rational associations in his mind of a reflection of reality.

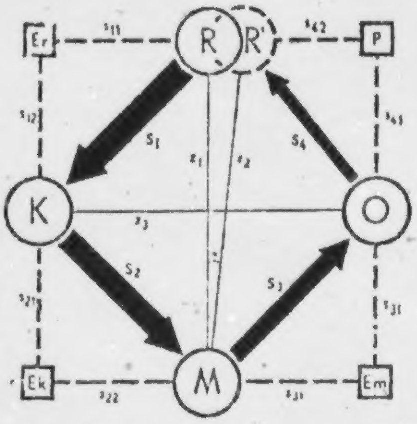


Fig. 1 – Model of cartographical transmission

R – reality as source of direct information
Er – informative emission of direct source
S_1 – relation of direct recognition
s_{11} – relation of direct emitting
s_{12} – relation of direct perceiving
K – cartographer, sender of message
E_k – message emission
(informative emission of sender)
S_2 – relation of message creating
s_{21} – relation of message emitting
s_{22} – relation of message perceiving
M – map or message informant
S_3 – relation of indirect recognition
(by means of a map)
s_{31} – relation of indirect emitting
s_{32} – relation of indirect perceiving
O – receiver (map user)
P – mental transformation
(mental processes)
S_4 – relation of reality image reconstruction
(relation of recognition)
s_{41} – relation of recalling
s_{42} – relation of imagination
R^1 – imagination of reality
z_1 – message relation
z_2 – relation of identification
(relation of map efficiency)
z_3 – relation of making available
(relation of informing receiver)
α – degree of transmission correctness

Fig.8 RATAJSKI'S MODEL OF CARTOGRAPHIC COMMUNICATION

Ratajski's model differs from Kolacny's in its emphasis on the direct and indirect means by which cartographic information is acquired, transmitted and received. It also differs in its greater concern for information loss during the cartographic communication process. The influence of Kolacny's model is evident also in the simplification used by Salichtchev (1973:106-111).

Bosowski (1975) stresses the dialogue between the map author (the cartographer) and the map user. Her model, (Figure 9) although more simplified than either Kolacny or Ratajski, is useful in providing insights of the means by which the map author encodes his cartographic message and the map user receives this information as one means of understanding reality. Bosowski stresses the role of the map as a vehicle for cartographic

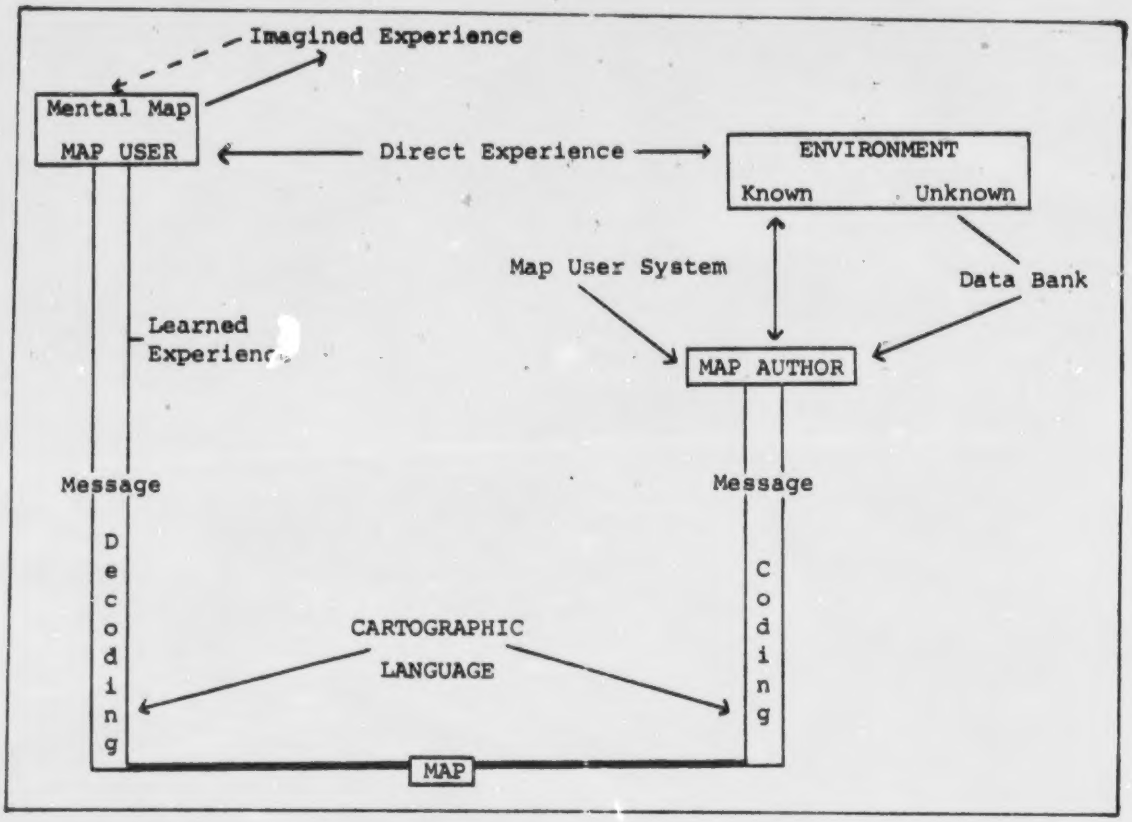

Imagined Experience
Mental Map
MAP USER
Direct Experience
ENVIRONMENT
Known
Unknown
Map User System
Data Bank
Learned Experience
MAP AUTHOR
Message
Message
Decoding
Coding
CARTOGRAPHIC LANGUAGE
MAP

Fig. 9 BOSOWSKI'S MODEL OF THE CARTOGRAPHIC COMMUNICATION SYSTEM

communication. Cartographic language is the means by which encoding and decoding of cartographic information can be achieved. Her model does not discuss the factors which interfere with and often distort cartographic messages.

The above models stress the substantive aspects of the cartographic communication process. Muehrcke (1969:3 and 1970:199-200) created a simpler model which highlighted the operations involved in the cartographic processing system (Figure 10). The key transformations he identifies in his model are:

i) the selection of information from the real world (T_1),

ii) the transformation of the selected raw information into a map (T_2), and

iii) the retrieval of the cartographic message from the map through map reading (T_3).

Theoretically, the output for T_3 should equal the input to T_2. The challenge for the cartographer is to create maps good enough for this to occur. Map user characteristics ensure that the achievement of this goal is virtually impossible.

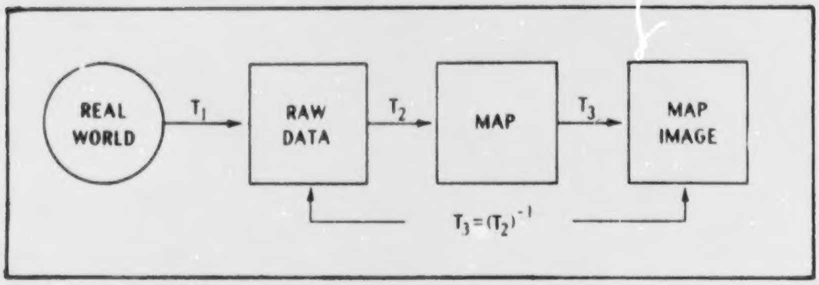
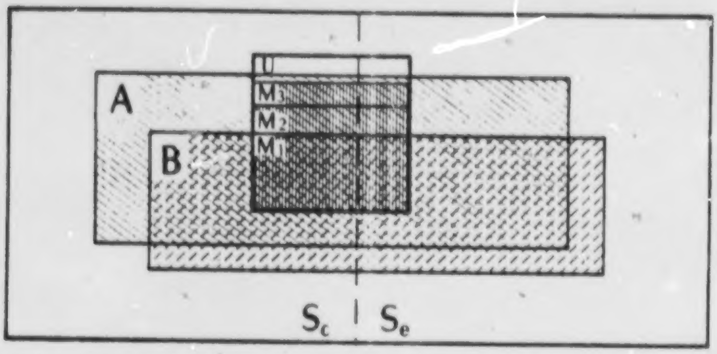


Fig.10 MUEHRCKE'S MODEL OF THE CARTOGRAPHIC PROCESSIN
SYSTEM

Robinson and Petchenik (1976:32-35) have produced a model of the cognitive elements in cartographic communication. The model includes both the flows and the operations involved in this process. Unlike the other models which are of a linear or a flow nature, Robinson and Petchenik's model is a rectangular version of a Venn diagram (Figure 11). This model indicates that both cartographer and map user (percipient) possess images of reality which contain accurate and erroneous images. Because of his experiences, the cartographer is expected to possess a larger, more accurate image of reality (the milieu). The graphic representation of reality by the cartographer (M) consists of a redundant fraction (M_1) already held by the map user, a new body of cartographic information comprehended by the map user (M_2) and some cartographic information not comprehended by the map user (M_3). Finally, the map user and the cartographer may improve their concept of space as a consequence of the map (U). The model is comprehensive in its elaboration of the cognitive aspects of the process. It stresses some loss of information (M_3) through noise. In graphic terms, the model does not indicate the flow of transformations as clearly as those of Kolacny or Ratajski.



A Venn diagram summarizing the cognitive elements in cartographic communication. In the terminology below, *Cr* refers to the cartographer and *Pt* to the percipient. Diagram elements are as follows:

S = Geographical space, the milieu
S_c = Correct conception of the milieu
S_e = Erroneous conception of the milieu
A = Conception of the milieu held by *Cr*
B = Conception of the milieu held by *Pt*
M = Map prepared by *Cr* and viewed by *Pt*
M_1 = Fraction of M previously conceived by *Pt*
M_2 = Fraction of M not previously conceived by *Pt* and newly comprehended by him: an indirect increment
M_3 = Fraction of M not comprehended by *Pt*
U = Increase in conception of S by *Pt* not directly portrayed by M but which occurs as a consequence of M: an indirect increment

Fig. 11 ROBINSON AND PETCHENIK'S MODEL OF THE COGNITIVE ELEMENTS IN CARTOGRAPHIC COMMUNICATION

Balogun (1978:71-82) has developed a Cartographic Information Transferral model in which he claims to concentrate on the amount of and factors affecting cartographic information at each stage of communication. The Balogun model (Figure 12) focuses on potential cartographic information (the amount of information which the cartographer selects for mapping), latent cartographic information (the amount of information which survives cartographic abstraction and is actually put on the map) and retrieved cartographic information (the maximum information extracted from the map by the map user). Balogun lays stress on cartographic information because, as Kolacny (1969) also realises, it is the keyword of the entire cartographic communication process. The concept of potential cartographic information considers the fact that the cartographer is not necessarily a primary data collector. It consists of the information pieces of all the phenomena to be mapped plus the usual base data of boundaries and other essential elements. Usually the latent cartographic information is less than potential cartographic information because generalisation has taken place and information loss has occurred. The amount and quality of retrieved cartographic information obtained by the map user is influenced by a number of factors - visual perception of symbols, general experience in map interpretation, age, education, cultural background, imaginative ability, interest and temperament - which are characteristics of the map user and his environment. Balogun's model relates the information at different stages. Since the model points out most of the factors influencing cartographic information at each stage, the cartographer can recognise the area where adjustment is desired. If the retrieved cartographic information is markedly different from the potential cartographic information, Balogun indicates there are two checkpoints for determining the cause of this discrepancy - the information processing and mapping procedures which are dominated by the generalisation process and the factors which may affect the retrieval of the information from the map.

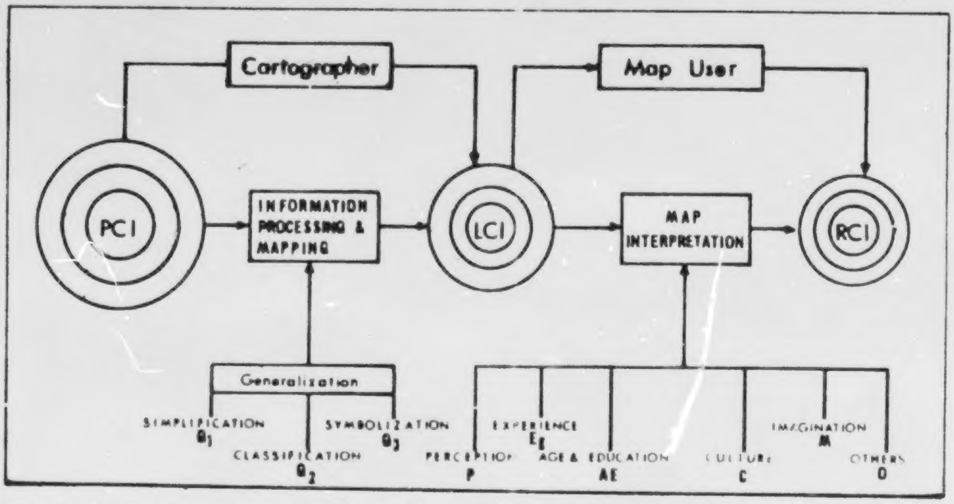

Cartographer
Map User
PCI
INFORMATION PROCESSING & MAPPING
LCI
MAP INTERPRETATION
RCI
Generalization
SIMPLIFICATION G_1
CLASSIFICATION G_2
SYMBOLIZATION G_3
PERCEPTION P
EXPERIENCE E_E
AGE & EDUCATION AE
CULTURE C
IMAGINATION M
OTHERS O

Fig.12 BALOGUN'S MODEL FOR CARTOGRAPHIC INFORMATION TRANSFERRAL

All of these models, despite their emphases, have four common attributes which form the basis of cartographic communication:

i) reality from which the cartographer selects appropropriate information,

ii) the cartographer's conception of reality which is the cartographic message to be transmitted,

iii) the map which is the graphic presentation using cartographic language of the cartographer's message ,and

iv) the map user's conception of reality as derived from the information represented in the map.

How well the message is transmitted and received depends on the attributes and competencies of the protagonists in the cartographic communication process , the cartographer and the map user.

These models of cartographic communication give strong weight to the concept of cartographic communication. There have been critics of this concept. They are best summed up by Blaut who proposes that there are six "serious" limitations to cartographic communication:

i) Maps artificially segregate the spatial aspect, and largely ignore the temporal aspects, of space-time reality. Therefore, it is difficult to portray change using maps. Arrows and date labels may be used to portray change on maps but they do not encapsulate the continuous flow of time.

ii) Not all distributions can be mapped accurately. Therefore, the orderliness which characterises maps is not possible. Numerous classes of objects may intermingle in an area. Unless they are drawn at a very large scale, maps of these objects can present only a limited locational record.

iii) Mapped boundaries are often arbitrary and misleading, since the cartographic line symbol is highly assertive and the symbolisation of inter-regional gradations is awkward.

iv) The map is a two-dimensional abstraction, and therefore fails in many cases to portray vertical relationships and stratification adequately, e.g. maps of large urban areas do not account for the vertical development in the business district.

v) Maps visually suggest direct causal relations where none may exist. Co-variance need not imply causal relations. Maps showing a few geographic elements at a time give no clue to influences such as complex cultural factors.

vi) Maps employ a limited number of symbols; each must be defined in words and generally signifies

> a complex idea which must be explained in words. The intention expressed here is that mapping is a subordinate language, conceptually simpler than, and logically dependent on, the language of words. (Blaut, 1954: 9-11)

Underlying most of these criticisms is the problem of the generalisation of cartographic information as the cartographer selects the relevant information for his cartographic message from all the information available in the area being mapped. The cartographer will become more knowledgeable in codifying cartographic information as more research is carried out into the manner the map user extracts information from maps. Technological progress should also provide the cartographer with the physical conditions to improve his message. Despite these criticisms, the concept of cartographic communication is a realistic one which was responsible for informing many a cartographer that he was actually communicating with someone rather then creating maps for esoteric reasons.

2.33 Relevance of information theory.

The unique quality of maps as information carriers arises from a number of factors including: the large areas covered for a given scale; the three-dimensional nature of representation by methods such as contour lines, heights and hill-shading; their permanence and fidelity; the one-to-one correspondence between objects represented and symbols or their location; the filtering involved in the design and selection process and the aesthetic appeal of a multi-coloured map (Balasubramanyan, 1971:177).

Information theory is concerned with measuring changes in knowledge. Its key is that knowledge can be represented by means of pictures, sentences, models or the like. Information received causes changes in the symbolic picture or representation used to depict knowledge (Mackay, 1969:156). In the mathematical sense of the theory, it is limited to discrete signals (those signals which have certain restricted values) (Young, 1971:6). The amount of information conveyed by the message increases as the amount of uncertainty as to what message will be produced becomes greater (Pierce, 1962:23). The more we know about what message the source will produce, the less will be the uncertainty and the less the information.

Taylor (1975), in a survey of the cartographic applications of information theory, found that they had been restricted to "measurements of the information content or capacity of maps", e.g. Balasubramanyan, 1971; Gokham and Meckler, 1971; Molineux, 1974, Srnka, 1970 and Sukhov, 1970. Taylor (1975:165) concludes that the findings in the measurement of information in other visual displays, e.g. Edwards (1964) and Klemmer and Frick (1953), are applicable to maps. When information theory is applied to visual displays such as maps, the display is conceived as a series of stimuli, corresponding to map symbols, which are the system inputs. These stimuli elicit responses (outputs) which correspond to symbol meanings. The map user (the information channel) links the stimuli and the responses. Then the amount of information or uncertainty can be measured at both input and output ends. Therefore, both the map symbols and their meanings are sources of measurable information or uncertainty (Taylor, 1975:165). Taylor, using Ratajski's structural model (1975) in an experiment concerned with the evaluation of topographic map symbols, demonstrated that principles of information theory can be used to evaluate the efficiency of the map- map user stage and the cartographer-map stage (Taylor, 1975:169-179). The efficiency of the map user - reality stage is assessed by studying the effects of cartographic information on the map user's interaction with his environment and on his conceptualisation of reality. McGrath's studies of navigational performance (1970) and McCleary and Westbrook's study of mental maps (1974) are examples of such research.

The contents of maps must be quantified if information theory is to be applied widely to maps. Sukhov (1970:46) sees such quantification as necessary in the generalisation process and for the automation of the processes of map and atlas plotting.

The case against using information theory in cartography has not been researched in the cartographic arena, but analogous observations may be drawn from the figure perception analysts in psychology because of the close link between map perception and figure perception. Green and Courtis (1966:12) state that before information theory can legitimately be addressed to any problem there needs to be:

i) an agreed alphabet of signs with known and constant probabilities of occurrence ,and

ii) objectivity of the probabilities.

For figure perception, no such definable alphabet exists unless the researcher defines the alphabet and imposes a temporal sequence on the presentation of these elements to the subject. Attneave (1954), for example, defined his elements as small squares of three different colours. By imposing a sequence of presentation, Attneave imposed arbitrary conditions which bore little resemblance to the normally haphazard process of figure perception. The question of objectivity has been glossed over by assuming that subjective probabilities mirror objective probabilities. Researchers, including Attneave (1953), have shown that,although there are links between subjective and objective probabilities,there are major discrepancies between them.

The linearity in the sequence of information components normally associated with traditional information theory is quite different from the sequence used on a two-dimensional figure such as a map. In figure perception the gathering of information is non-sequential. Information is gathered in localised blocks which correspond with the fixation points of the observer's eyes as they jump about over the map space. Such patterns are varied and unreliable (Fleming, 1969: Jenks, 1973; Noton and Stark, 1971; Yarbas, 1967 and Zusne, 1970).

One can subdivide a figure such as a map into pieces for evaluation or analysis, but this is not how the map user sees the map. The map user sees the map as a whole. Therefore, in real life the location and amount of information perceived is a function of the map user.

Robinson and Petchenik also stress the utilisation of blank spaces on maps as another parallel between map perception and figure perception and as a difference from the traditional scientific approach to information processing (Robinson and Petchenik, 1976:40). Green and Courtis (1966:20-27) refer to the inferences that can be drawn from blank spaces in cartoons. Robinson and Petchenik refer to notable "blank" areas on maps, e.g. flood plains and deserts (depending on the scale of the map), which, although being blank and homogeneous provide considerable information by inference to experienced geographers. According to information theory these "blank" areas contain zero bits of information.

Therefore, while a number of researchers have illustrated ways of measuring some of the information contained in maps, traditional scientific information theory is not applicable to maps or other forms of figure perception because the information on these figures is in no way similar to that of a coded sequential message consisting of discrete, quantifiable signals. The situation will not change until cartographic language can be standardised.

2.34 The cartographer and map design.

> "A map may be like a person who talks clearly and convincingly on a subject of which his knowledge is imperfect. We tend to assume too readily that the depiction of the arrangement of things on the earth's surface on a map is equivalent to a photograph - which, of course, is by no means the case. The object before the camera draws its own image through the operation of optical and chemical processes. The image on a map is drawn by human hands, controlled by the operations in a human mind."
>
> (Wright, 1942: 527)

Cartographers are human and their map designs reflect their scientific integrity, judgment, ability to generalise and their aesthetics. Since the cartographer is one half of the cartographic communication duo, his role is vital in making the process possible. According to Bowman (1968:34-47), the design process in graphic communication relates to thirteen basic communicative aims which answer the questions:

- i) To show what?
  - a) appearance (the natural features of the subject seen by the eye),
  - b) structure (the essential physical constitution of the subject),
  - c) organisation (the logical interrelationship of elements in terms of the whole);
- ii) To show how?
  - a) movement (the physical action or behavioural pattern of a subject in motion),
  - b) system (the pattern of operation of a subject in terms of its interrelated elements),
  - c) process (the procedure of independent subject actions as a succession of related events),
  - d) size (the physical extent of a subject with respect to the space it occupies),
  - e) quantity (the amount of a subject in terms of a fixed scale of measure),
  - f) trend (the progressive increase or decrease of a subject in amount),

g) division (the separation of the whole in terms of its component parts);

iii) To show where? a) area (the space occupied by a subject in relation to its natural surrounds),

b) location (the spatial relationship between the subject and its overall environment), and

c) position (the spatial relation of a subject element to other elements within an area).

Cartographers create maps to show what, how and where of phenomena on the surface of areas.

The cartographer's purpose in creating maps is to communicate cartographic information effectively to the map user. Therefore, the cartographer should consider user conditions, level of user understanding, circumstances of use, complexity of the information, the technical possibilities and their cost (Keates, 1973:29). The choice and arrangement of the graphic aspects of a map should include clarity, legibility, contrast, colour and balance (Wood, 1972:125).

Early research into map design focused on the appearance of individual signs. Flannery (1956 and 1971) experimented with graduated point symbols and found that graduated circles were the best type of quantitative point-symbol perceived. Meihofer (1969) concluded that range-graded circles were more useful and more effective than graduated circles. Crawford (1971) working with both graduated circles and lines found that grey signs are better than black counterparts because they enabled the cartographer to expand the amount of information that can be shown clearly on a single monochromatic map and they allowed greater freedom of expression in map design and symbolisation. Ekman et al.(1961) concluded that volumetric symbols are perceived as two-dimensional area symbols and not in three dimensions.

These studies extended to studies of area signs via studies of choropleth maps. Jenks and Caspell (1971) considered error in choropleth maps and concluded that an increase in visual static was produced by an increase in the number of classes on a choropleth map. Monmonier (1974, 1975) investigated pattern complexity and class intervals in choropleth maps. Monmonier concluded that, unlike the psychologist, the cartographer is concerned with figures more complicated than two class square grid patterns in pattern complexity. In class intervals, he found that consideration should be given to within-class homogeneity and there should be preference for whole numbers in determining breaks between categories. Dahlberg (1967) investigated the dot map and concluded with a plea for more base data on dot maps, as well as the necessity for the cartographer to include factors relevant to the distribution or to the user's mental map of the area.

Considerable research has been undertaken regarding the class intervals in thematic maps. Jenks and Knos (1961: 332) concluded that the Williams' curve represented the best range of class intervals on the grey spectrum. Kimmerling (1975), researching equal-value grey scales, concluded that cartographers are concerned with such scales to select the best scale for a map whilst psychologists search for explanations of the relationship to fit the relationship to psychophysical law. Jenks and Coulson (1963:120) state that class intervals should: (a) encompass the full range of information; (b) have neither overlapping values nor vacant classes; (c) be sufficiently numerous to avoid sacrificing the accuracy of the information, but not too numerous as to give excessive accuracy; (d) have reasonably equal groups of observations, and (e) possess a logico-mathematical relationship. Schultz (1961) concludes that in selecting intervals, cartographers should avoid "islands", beware of quartiles and use natural breaks when they occur, but ultimately it is the cartographer's conscience which decides.

Clarke's six recommendations made as long ago as 1957 still serve as outcomes of the above research.

i) Each map should include only one type of symbol (so as not to overtax the visual perception of the map user).

ii) The cartographer, after examining the numerical range of the cartographic information, should select a symbol according to the ease of visual evaluation, ease of construction and adequacy for location.

iii) Visual evaluation is improved by the use of one symbol in standard sizes, all of which are shown in the key, e.g. the population of urban areas.

iv) Great care should be taken in constructing the legend because of map users' difficulties in visually evaluating proportional symbols.

v) Avoid overlapping symbols by making larger-scale insets.

vi) Use only the place names which are indespensable to understanding the map, because they influence the impression of distribution.

(Clark, 1959: 102-104)

Williams (1972:148) adds to these in his rules governing the displacement of line and area signs on maps. For line signs, he concludes:

i) The centre of the sign should correspond with the position of the centre on the ground and the orientation of the sign should correspond with the orientation of the feature on the ground.

ii) If a group of signs are "exploded", the shape and orientation of the group should be maintained.

iii) Linear features should be displaced evenly from the group of features and the orientation of the features maintained.

Area signs should be used to show features covering large areas on the ground which cannot be depicted by line or point signs.

Although the above research is continuing, there has been a trend to study the overall organisation of map elements. Robinson (1952), stressed the overall appearance of maps in regard to map structure, lettering, the use of colour and the design of the map as an art form. Imhof (1963) indicated that although cartography is a pictorial form of art, having qualities of clarity of graphic arrangement, highest degree of expression, balance and simplicity, its freedom is limited by the use of conventional colours and symbols. Imhof's major contribution has been in the placement of lettering on maps (1962). This will be elaborated in the segment on map lettering.

The recent research into the overall organisation of map elements, typified by Dent (1972) and Wood (1968), has borrowed from psychology the concepts of figure-ground relationship and Gestalt laws of organisation. The figure-ground relationship, used mainly on thematic maps, describes the discrimination of a figure from an amorphous background (Forgus, 1966:107). Hebb (1949) noted three aspects of the figure-ground segregation necessary for perception : a primitive, sensorially determined unity in which the segregation of the figure from the background is a direct product of the pattern of sensory excitation and the coding strategies of the visual nervous system; a non-sensory unity affected be experience in which a perceiver responds selectively to a portion of the visual field; and the identity of a perceived figure, affected by experience.

Gestalt laws of organisation - size (the smaller areas catch the attention), proximity (items, close together, are seen as distinct groups), closedness (closed outlines produce clearer figures), symmetry (the most symmetrical pattern seems to dominate) and good continuity (the more continuous an element the more clearly it is seen) - state the qualities of an image most likely to make it stand out as a "figure" (Haber and Hershenson, 1973:188-190). Maps consist of a variety of superimposed and overlapping signs. Any sign or class of sign may be designated a"figure". Therefore, the figure-ground relationship may be influenced by the cluttering of signs and labels (i.e. background noise) on a map (Wood, 1972:126). Zusne (1970:118) has concluded:

> "..... when the degree of organisation in the ground is about the same as that in the figure the reversible figure/ground relationship results."

If cartographers are to minimise difficulties in the figure-ground relationship, they should design maps around a hierarchy of visual planes of symbolic information. This will improve the clarity and legibility of their maps (Dent, 1972; Robinson and Sale, 1969:267; Saunders, 1958; Spiess, 1971).

Quantitative studies into the overall organisation of maps have been made, in addition to the descriptive psychological research. Olson (1975) made a study of autocorrelation (the total look of a map) and visual map complexity. The use of the concept of autocorrelation enabled Olson to focus on the degree of organisation on maps by pairwise listing of neighouring values. The results of the research suggested that map users' concepts of spatial complexity are related to certain objective measures of the relationship between neighbouring values. Muehrcke (1973), in a study of visual pattern comparison (the map user's response to the map as a whole), indicated the significance of map complexity, map complexity multiplied by cartographic technique,and map user experience. McCarty and Salisbury (1961) suggested general guidelines for selecting optimal combinations of map variables to facilitate visual map comparison.

Therefore, in designing maps, the cartographer should employ a number of principles. Keates (1973: 30-31) states that these principles are concerned with content, visual levels, contrast and balance:

i) The content of the map must be thoroughly examined in respect of the range of physical features and artificial features, the special subject matter and its sub-classifications, the areas characterised by dense distributions and sparse distributions, and the overlap of one distribution with another.

ii) All map designs should contain more than one visual level (i.e. possess a figure-ground relationship). This is achieved by controlling emphasis and contrast in the design of the symbols and on a basis of separation of subject matter. These levels are influenced by colour contrast, line weight and the treatment of surface colour as applied to areas.

iii) The initial design should employ the minimum degree of contrast necessary to make all symbols perceptible, and dominant symbols dominant. Initial overcontrast of line and colour will produce heavy, unattractive designs.

These principles of map design are made more meaningful by considering the various monocular cues of depth. Vernon (1962:94) lists these as:

i) relative sizes of the retinal images on different parts of the field,

ii) relative brightness, clearness, and colour saturation of different parts of the field,

iii) perspective effects, overlapping planes, shadows and the general structural arrangement of the field, and

iv) previous knowledge of and familiarity with the spatial arrangement of the field.

Gibson (1950) suggested that these cues could be understood under the concept of "stimulus gradient" (Surfaces in the visual world have textures: the greater the distance away the greater the density of the texture on the retina). Kopferman (1930) demonstrated that if patterns on two planes were similar and seemed to fit together, they were seen on the same plane. Gibson (1969:401) and Gibson and Walk (1960) explained the difficulties in perceiving depth in pictures via the concept of the "visual cliff".

By applying these cues the cartographer can create the illusion of depth. He can adjust the quality and relative sizes of signs on his maps. By using richer colours (maximum saturation) the cartographer can establish the figural aspect on the map and by using paler tints he can depict background aspects. By varying sign size, line thickness, texture and place names, the cartographer can apply the "depth-cue" approach to a map image, especially a thematic map image.

To assist the design process, Wood (1968:61) states that some order ought to be established concerning the visual planes observed on any map. Since no order can be derived from the reading of maps, Wood states that the four aspects of this ordering of visual planes on maps are:

i) The sea is the least important therefore it should be drawn in blue which is one of the Gestalt soft colours suited to backgrounds. The names of sea areas should be printed in blue to associate them visually with the sea.

ii) The land and associated features should clearly contrast with the sea in the sense that the land is rendered as a definite "figure". Head's research on land-sea differentiation indicates the confusion map users have in this regard. Head suggests that the land must dominate as a strong "figure" and, where possible, the horizontal lettering on maps should be restricted to land areas (Head 1972:37).

iii) Cultural features (urban areas, roads and railways) are important. Their importance should be noted via the use of rich colours (red and/or black).

iv) Political units or boundaries are delineated best by the increased thickness of lines.

Wood illustrated how these planes might be achieved in a residential land use map of Glasgow (1968:62).

Three key design aspects which the cartographer, therefore, must consider carefully when designing maps are: generalisation, lettering and colour.

The process of generalisation, mentioned earlier in 2:10, is inherent in all maps because the cartographer must select the relevant cartographic information to insert on his map. The scale of the map determines the amount of information to be included. Therefore, reduction in the scale of a map automatically means increased generalisation. Information on a map has location and meaning. The number of classes and sub-classes of this information is affected by generalisation. For example, on a 1:50,000 map the cartographer can depict five or six types of roads, but on a 1:1,000,000 map only the most important roads can be included.

Morrison (1974:118-126) has quantified the relationships between the four generalisation process defined by Robinson and Sale : simplification, classification, induction and symbolisation. These relationships are seen in terms of the transformations which occur between the four processes. Morrison quantifies these transformations as "one-to-one" (distinct elements have distinct images) and "into" (generalisation of elements take place). Therefore, the resultant transformations are: simplification -"one-to-one" and "onto"; classification - "onto" only; symbolisation - "one-to-one"; and induction - nil. Morrison extends this quantified approach to generalisation to the categories of symbols used on maps. Such an approach could form the basis for the standardisation of cartographic symbols.

As a synthesis of the research into map generalisation, Keates (1973:26-28) proposes six principles in the process of generalisation which cartographers should heed in designing maps:

i) adequate information (If the information is to be selected from the total for an area, the total distribution must be understood first of all. One generalisation should not be based on another. Therefore small-scale maps are not good bases for generalisation.),

ii) size (With scale reduction, the cartographer must maintain the true geographical characteristics of the area, even if this requires combination, exaggeration and displacement.),

iii) classification (Careful consideration must be given to the relationship between selection and classification of cartographic information so that if minor classes of information, e.g. minor roads, are omitted, the classification of information is adjusted, e.g. three more inclusive classes of roads than five precise classes.),

iv) adjacency (Features which belong to one class, e.g. small areas of woodland and forest, can be grouped together, whilst features which are separated by different major elements, e.g. small islands, cannot be grouped together.),

v) correct form (Each sign placed on a generalised map should reflect in a specified form the most important characteristic of the feature. A meandering river should be characterised by a wiggly blue line at small scales even if it means slight enlargement and displacement of particular meanders. Cartographers should possess a sound knowledge of geography or should investigate such knowledge when mapping an unfamiliar area.), and

vi) balance (Since topographic features are related to each other and because all other phenomena are related to these features, the balance of generalisation between different features must be controlled. The temptation to undergeneralise where there is available space and to overgeneralise where features are crowded together must be avoided. For example, on a topographic map, a detailed representation of the drainage pattern should not be combined with a simplified treatment of relief).

The cartographer's use of type (lettering) on a map is important because the use of type on maps is unique in several ways. Cartographic type as a medium of communication, deals with specific, unique place labels which have no essential connection with one another. Verbal language type, on the other hand, consists of conventional geometrical forms arranged in a prescribed manner (in a alphabet). The arrangement of the shapes of words on a map and the physical characteristics of the type style may encode considerable information. Map type is transparent (in the Polanyian sense) since the map user is expected to look both through the type and at the lettering (Bartz, 1969:129-130).

Bartz (1969:130-133) explains that map type may be analogous and non-analogous with reality. It is analogous with reality in terms of location, quality and quantity (value). Cartographic type is arranged on a map in a manner physically analogous to the actual location of these objects in an area. Since it is unlikely that any particular name will occur in the same place more than once, the location of any name on a newly-encountered map will involve a search. Map type may be qualitatively analogous to reality in that blue italics are normally used for labels of hydrographic features (i.e. the type adopts some of the visual characteristics of classes of objects). Quantity analogy is evident in the variation in height and boldness of type used to locate urban areas of different size, e.g. Sydney and Melbourne may be named using 4-point type and Birdsville using 24-point type. The value analogy occurs when comparisons of size are made among classes of information or when arbitary hierarchies are established within a category, e.g. to highlight one country in the South Pacific, e.g. Fiji, its name would be printed in the boldest type on the map.

The arbitrary (non-analogous) characteristics of map type are found in the symbolic use of such type. Bartz (1969:133) has indicated that the arbitrary selection of map type may be represented by a continuum ranging from purely symbolic to purely analogic. Type style and form are commonly used in purely symbolic usage of type, whilst type arrangement, boldness and height are used for purely analogic type.

Map type also has the function of providing some indication of scale. The variations in type and line weight provide cues of scale. Map users become aware of this when they sense error on the map in relation to the scale range they know exists (Bartz, 1969:134). There are no definitive research findings to validate Bartz' view.

The question of type legibility on maps has not been researched by a large number of people, but those who have done so have been thorough. Robinson (1952) was the first researcher to point out the value of and the need for empirical research into cartographic type selection. In a latter publication, Robinson (1960) wrote of lettering as one of the symbol systems contained on a map and expressed concern for the legibility, visibility and perceptibility of type selection. Keates (1958 and 1973:177-180), besides listing differences between cartographic and conventional type, has detailed the characteristics he would like to see included in the design of typeface for maps. He places emphasis on the arrangement of names, the weight of lettering and type contrast.

Imhof (1962) has provided the most comprehensive statement on the positioning of names on maps. He stresses that lettering on a map involves linguistic, geographical, graphic, aesthetic and technical aspects. The good arrangement of names on a map, besides facilitating the reading of the map, heightens its graphic and aesthetic aspects. Imhof listed six general viewpoints and regulations regarding the positioning of letters on a map:

i) Names should remain easily legible, easy to distinguish , and easy to locate. The readability of names on a map depends on typography, colour, arrangement and ordering of names.

ii) It should be easy to find which object belongs to a name. This entails limiting the height of the type.

iii) Names should not work against the contents of a map. The cartographer should avoid covering the

the contents of a map with a name or cutting up the contents by the poor positioning of names.

iv) Names should help to arrange the viewpoint and the differentiation of objects on a map.

v) The arrangement of type should remain fluid. The name should mirror the object on the map. This can be achieved through a variation of type and height of typography.

vi) The map should not be covered by names in a very regular form. Bunching up of names should also be avoided. (Imhof, 1962:95)

When describing the type on a map, Imhof recognises three types of description : point description (the position of points which varies with the scale of the map), line description (names arranged in band form),and area description (the arrangement of names inside an area to indicate the form and expanse of an area). For each of these types of description, Imhof promulgates a series of rules concerning their positioning, e.g. he posits nine rules for linear descriptions (1962:106).

Imhof places emphasis on the spacing of letters on maps. He accepts the Zoepprits - Bludau rule that the width of spacing should not exceed two times the height of letters. Also, letters should always follow each other in a manner that they can be grasped as one composite and can be seen as belonging together. Spacing has to conform to optical and visual viewpoints, and it is not always geometrically the same (Imhof, 1962:115-116).

Finally, Imhof offers advice for the combination of type with the rest of the map contents (1962:122). He states that the cartographer should avoid covering names with important objects; isolines should be broken under a name, letter or figure, and the names in shaded areas should not detract from the light-shade contrast.

It is debatable how well cartographers have adhered to the above suggestions to improve the legibility and arrangement of type on maps. More adherence is necessary to aid the map user to decode the perceived cartographic message. Technical constraints in the methods for superimposing type on maps and the expertise of the cartographer also influence the effectiveness of type used on maps.

Colour is one attribute of a map which attracts map users. Robinson (1967:50) noted that colour is the most frustrating map element to the cartographer.

> "There is a possibility that we are dealing with a generation of students conditioned by colour television and that colour may be a prerequisite if optimum interest is aroused in a learning situation." (Dwyer, 1976:60)

In purely psychological terms, colour affects our ability to differentiate among objects; changes our moods and feelings; distorts our preferences and influences our aesthetic experiences (Haber and Hershenson, 1973:60). Researchers note that when colour is applied to maps, it functions:

i) to simplify and to clarify the map as a visual focus and a unifying agent (Nunez de las Cuevas, 1967; Robinson, 1967);

ii) to give the map user a good plastic representation of terrain (Nunez de las Cuevas, 1967);

iii) to have a major effect on the subjective reactions of the map user causing the expression of feelings towards the map (Keates, 1962; Robinson, 1967);

iv) to beautify the art of cartography (Nunez de las Cuevas, 1967);

v) to effect the general perceptibility of the map via the legibility of map lettering and the user's visual acuity (i.e. the ability to distinguish fine detail), (Robinson, 1967); and

vi) as an attribute of cartographic signs to improve the efficiency of the receipt of cartographic information (Makowski, 1967).

Since colour on maps, as on other graphic presentations, acts as a physical stimulus, map users respond to its dimensions with physiologic - perceptual reaction. These dimensions of hue (the chromatic colour quality indicated by its name, e.g. blue), value (the relation of a colour to white and to black, e.g. light blue), and intensity (the colour strength of a hue as compared with a colourless grey, e.g. brilliant blue), help map users distinguish phenomena (Sargent, 1964:6). Robinson (1967:53-57) investigated physiological-based perceptual aspects (i.e. the ways in which the appreciation of colour hue, value and intensity differences are affected by (a) physiological mechanisms including acuity, sensitivity and simultaneous contrast), (b) connotative and subjective aspects (i.e. the intellect modifies the elementary response to physical stimuli of colour via symbolic connotations, implications of magnitude and dominance of extremes) and (c) conventional aspects of colour. Robinson's three generalisations from this study should influence cartographic design:

i) Psychologically, the dimensions of hue, value and intensity are not accepted equally. Hue is the most interesting dimension for it leads to a variety of conventions and is generally controversial. Value is the most important in terms of the map user's behaviour, especially toward the figure-ground relationship and legibility. It is basic to the recognition of form. Intensity is insignificant compared with hue or value.

ii) The three kinds of responses to colour - physiological - perceptual, connotative - subjective and conventional - produce basic conflicts and problems. For example, conventionally green represents lowland in elevation classes and green also suggests fertility. But what can be done for a barren lowland or a fertile upland?

iii) Because of the complexity of the map user's perceptual response to colour and of the variety of uses of colour in cartography, there is a need to be wary of establishing additional colour conventions in cartography.

(Robinson, 1967:58)

Page (1974) and Wood (1968) have documented influential factors on colour perception. Their lists include contrast, spectral relationships in the visual field, visibility, legibility, psychological factors such as the figure-ground relationship, age, colour temperature of light sources, viewing location and length of observation time. The most important factor is colour contrast which produces erroneous perceptions of hue, value and intensity.

Research has been completed on the comparison of colour with black-and-white in graphic presentations. Studies by Deutschmann, Barrow and McMillan (1961), Katzman and Nyenhuis (1972), Kumata (1960) and Schaps and Guest (1968), indicate that coloured presentations tend to increase the acquisition of information peripheral to the main idea because the coloured presentations were perceived as being more active, more interesting and more emotional. Webster and Cox (1974) found that colour gives clues in the perception of figure and ground. Smith and Thomas (1964) concluded that colour was a better form of coding than shape coding for graphic signs.

Even so, there have been several studies which found no significant difference in achievement between colour and black-and-white. Studies by Kanner and Rosenstein (1960) and Vandermeer (1954) on the recall of visual and verbal material are typical examples.

From the cartographer's view, then, colour is vital. A synthesis of the conclusions by Cuff (1973), Keates (1962), Nunez de las Cuevas (1967) and Robinson (1967), indicate the following for consideration in map design:

i) Colour is a symbol which is used to facilitate reading, to obtain a more plastic effect and to beautify the map.

ii) The cartographer should aim for an harmonious composition of colours. For thematic maps the best scheme is dominated by a strictly quantitative progression of darkness and intensity.

iii) Line colours should be pure and intense for easy discrimination.

iv) For maps including hypsometric tints and shading, the Imhof principles of "the higher the lighter" should be employed.

v) In topographic maps, hypsometric tints indicating elevation of land and depth of water should consist of harmonious colours and be as neutral as possible.

vi) Even though colour-blindness is insignificant for females and limited to a small proportion of males (5% -8%), the cartographer should consider it when arranging the colours on any map.

vii) Cartographers should adopt a universal colour classification, e.g. Munsell's, for use on maps.

Despite the above conclusions on map design, the cartographer still experiences difficulties in producing his artistry. Christner and Ray (1961:131) summarised these to include: (a) the high amount of information which must be presented, (b) the constraint of retaining the spatial arrangement on a limited surface area, (c) the variety and levels of information portrayed and (d) the psychological implications of a visual hierarchy and the figure-ground relationship. Bartz (1970) has stressed that the visual hierarchy must be arranged to match intellectual hierarchy tasks expected of the map user. In the end, it is left to the cartographer to make his own subjective decision in designing maps.

2.35 The map user.

The role of the map user in the communication process has been detailed in Chapters 2.31 and 2.32. In summary, the map user is the other half in the communication process. He is the recipient of the numerous cartographic messages organised and presented in graphic form by the cartographer. He is also a very unpredictable element in the cartographic communication process because of his individuality.

As indicated in Chapter 2.34, there has been considerable, extensive research into the cartographer and map design. Research into the map user is fragmented with limited attempts to observe the map user as an entity. The majority of previous studies into the map user have focused on his ability to read maps. Rushdoony (1968) summarised the major research in this vein up until the mid 1960's. Brown et al.(1960) conducted a major investigation on behalf of the International Geographical Union on children's performance with maps. The performances were linked with chronological age. Bartz (1967) investigated children's preferences in reference maps Carswell (1970) investigated children's abilities with topographic maps. His research is noteworthy in that it sought to find relationships between map skills and attributes of the map user including intelligence, sex, spatial ability, socio-economic level, grade, age and teachers' knowledge of geography. Dale (1971) investigated children's reactions to maps and aerial photographs. Thake (1977) researched mapping concepts for seven-through-nine year old children.

It is now possible to generalise about the variables of the map user which influence the cartographic communication process. Balogun (1978) in his explanation of cartographic information transferral indicates that the map user's ability to read maps is influenced by his visual perception of symbols, his general experience with maps, his age and education, his cultural background, his imagination, interest and temperament. The actual functional relationship between these variables is complex, but together they influence the amount and the quality of cartographic information retrieved by the map user. Wood (1972) has also made an attempt to synthesise the "human factors" in cartographic communication. He stresses the role of visual perception, memory, spatial ability and map-reading ability. Blaut and Stea (1971) and Dale (1971) have both concluded that socio-economic level influences performance with maps. Robinson (1952) and Petchenik (1974) have concluded that children do have attitudes towards maps based on their impressions of the total look of the maps.

Whenever the individual draws maps he assumes the role of cartographer. This performance in mapping not only involves an understanding of space, but also the ability to draw. Eisner (1967) demonstrated the link between drawing, reading and intelligence. Harris (1963) indicated the link between drawing ability and cognition. Bell (1952) illustrated the link between drawing and perception.

Therefore, the map user characteristics worth considering in the cartographic communication process include spatial ability, visual perception, map-reading ability and understanding of the concept of a map, chronological age, drawing ability, previous experience with maps, attitudes towards maps and home environment.

Spatial Ability

Spatial ability (the capacity to perceive and hold in the mind the structure and proportions of a form or figure, grasped as a whole) is accepted as a major human ability (Wood, 1972:131). A person of high spatial ability grasps figures in relatively large units. His main concern is for the structure or form of the whole figure with little concern for the constituent elements of details (Smith, 1964:243; Vernon, 1947). Spatial ability consists of the ability to sense and retain geometrical forms and a facility in the mental manipulation of spatial relationships (Wood, 1972:131). McDaniel and Guay (1976) have proposed a four-stage hierarchy in the development of this ability:

i) the formation of a simple pattern from a limited series of stimuli, seen one at a time;

ii) the perception of a configuration and retention of that configuration in the mind despite distracting elements;

iii) the perception of a three-dimensional object and the conceptualisation of that object to describe portions of it that are not immediately visible.

iv) the conceptualisation of a three-dimensional object and its transformation into a two-dimensional representation.

Consequently, Wattanawaha (1977) developed her DIPT classification system which attempts to identify the most important general variables evident in the performance of spatial tasks - the dimension of thinking, the degree of internalisation of images, the mode of presentation and the thought processes demanded by the task.

An understanding of how children develop a concept of space is implicit in the development of spatial ability. Dominant in the approaches to the children's conception of space is that of Piaget and Inhelder (1956) whose sequence of topological, projective and Euclidean space has become a cornerstone in spatial cognition. Topological space is purely qualitative and contains no evidence of measurement except for simple relationships such as "inside", "outside" or "next to" (Piaget and Inhelder, 1956:450-463). Projective space adds to topological space the requisites of locating objects, or the elements of a single object, in relation to each other within a given perspective. Euclidean space co-ordinates objects among themselves with reference to a total framework or to a stable reference system which requires conservation of surfaces and distances (Piaget and Inhelder, 1956:247). Wattanawaha (1977:37) notes the similarity between projective and Euclidean space and Michael, Guilford, Fruchter and Zimmerman's SR-O and V_z factors (1957) - a link between the developmental psychologists and the factor analysts.

From the topological, projective, Euclidean sequence, Piaget and Inhelder (1956:454-455) developed their four major stages of spatial organisation : sensorimotor, preoperational, concrete operational and formal operational space. Sensorimotor space evolves and culminates in four simultaneous developments : the genesis of images, object permanence, movement in a single co-ordinated space within which all objects are interrelated and begin to be represented and the beginnings of internalised thought patterns (Piaget, 1954:3-218). Preoperational space involves preconceptual and intuitive, partially regulated thinking. Concrete operational space consists of the appearance of concrete operations and their organisation into logical structures. Formal operational space is characterised by spatial operations removed from real action, objects or space.

Most concern in this study is with concrete operational space which Piaget and Inhelder (1956:184-189) noted was developed by children aged seven through twelve years. In this stage children are becoming able to distinguish between viewpoints in their drawings. The children are beginning to show signs of being able to operate mentally on images. Reversibility of these mental operations is possible. The thinking is still concrete since it is dependent on the presence of real or represented objects. In their classic "Three Mountains" experiment, Piaget and Inhelder concluded that a child at the concrete operational stage realised the co-ordination of perspectives involved as the model was viewed from different positions (Piaget and Inhelder, 1956:242).

The Piagetian approach has been replicated widely in studies such as those by Laurendeau and Pinard (1970) who also made a summary of the mid-sixties research of a Piagetian nature (1970:19-20), Pufall and Shaw (1973), Steiner (1974) and Wallace (1965). Also, there has been a considerable number of studies whose results do not fit Piagetian theory. These include Cousens and Abravanal (1971), Dodwell (1971), Kidder (1976) and

Weaver (1972).

A number of researchers including Boe (1968), Collins (1976), Davies (1976) and Kidder (1976), reject the age of twelve years as the age at which formal operational space is established. Heamon (1973) and Rhys (1972), working within the field of geography, have concluded respectively that the age at which spatial maturity is reached is fourteen and 15+ years.

Other psychologists than Piaget and Inhelder, have presented theories or approaches to the concept of space. They include Werner, Bruner and newer theorists of the 1970s.

Werner is credited with the first comprehensive theory of space derived primarily from empirical findings. His "organismic—developmental" theory is based on the concept of orthogenesis which states that:

> "....insofar as development occurs in a process under consideration, there is a progression from a state of relative globality and lack of differentiation to a state of increasing differentiation, articulation, and hierarchic integration."
> (Werner, 1964:504)

The "organismic - developmental" theory consists of three levels : sensorimotor, perceptual and contemplative. Therefore, Werner sees spatial development as centred around the child rather than determined by an abstract system.

Bruner (1966) established three classes of spatial representation : enactive, ikonic and symbolic , which occur in the developing individual in the listed order. Enactive representation occurs when "action is flexibly goal-directed and capable of surpassing detours " (Bruner, 1966:11). Ikonic representation occurs when a medium of a mental image is the basis of the thought or action. Symbolic representation is evident when the individual is capable of recognizing and generalising concepts which are embodied in different physical concrete objects or experiences. Bruner sees language as the most specialised 'natural' system of symbolic activity (Hart and Moore, 1973:273).

During the 1970s new approaches to spatial ability were developed. Shepard and Metzler (1971) in their study on the mental rotation of three-dimensional objects introduced the concept of a mental analogy for action before spatial tasks could be completed. Therefore, the better the spatial ability one has, the more difficult mental transformations he can cope with spatially. This conclusion was verified by Shepard and Feng (1972).

Huttenlocher and Presson (1973), whilst investigating perspective and rotational problems, found that rotational problems were easier than perspective problems, even though no new information was available. They concluded that this was because the subject can imagine the array in a different position, but not himself. This study has Piagetian similarities, as has that by Fishbein, Lewis and Keiffer (1972) which was derived from the "three mountains" experiment. Their study focused on perspective and turning tasks. Like Huttenlocher and Presson, they found the turning task was better understood. These studies suggest that the Piagetian generalisations have not considered all of the variables in the child's co-ordination of perspective in space. These recent studies tend to seek newer directions and explanations whereas those of Werner and Bruner do not seem to be radically different from those of Piaget and Inhelder.

Visual Perception

The map user must be able to visualise the space represented on the map in order to decode the message transmitted by the map. Eliot (1970:265-266) states that the act of visualisation may be described as a perceptual - imaginal continuum:

- i) perception of the attributes of objects and their interrelationships,
- ii) recognition of a standard configuration amongst competing configurations,
- iii) the distinguishing of a transformation (displacement of the same configuration from a different orientation), and
- iv) the relation of the relationships of the transformed configuration to those of the standard one.

Therefore, the act of perception initiates spatial visualisation.

Perception is defined according to one's particular theory. A starting definition is that which Imperatore (1970:176) extracted from the Webster's New World Dictionary of the American Language: "the awareness of objects or other data through the medium of the senses "and as" insight or intuition, as of an abstract quality." A range of theories relating perception and cognition have been advanced. Gibson (1969 : 37 - 52) grouped these as: 1) probabilistic cue learning by Brunswik (1955) which proposed that perception is always of the distal object and since the environment provides only uncertain information in the stimuli reaching the senses, these stimuli act as cues of the real distal object; 2) transactional theories, e.g. Ames (1952) and Ittelson (1962), which emphasize the privacy of the individual's perceptual world and that perception is learned; and 3) judgmental and problem-solving theories including:the schemata theories of Bartlett (1932) and Vernon (1954,1955) which state that perception learning is the acquiring of schemata and involves the integration of experiences through association; Piaget (1960) who stressed that perception involves assimilation of sensory data into a schema; and Bruner (1957) who saw perception as being achieved by a sequence of operations including hypothesis, trial and check, and matching to a category. Wohlwill (1962: 74-77), in his summary of perceptual-cognition theories, also includes the Gestalt view on perception with its emphasis on the whole figure and the organisation of the figure, which is important in the study of graphic displays such as maps. To these theories, one may also add Gibson's psychophysical theory of perception as adaptiveness acquired through education (Gibson, 1970).

Visual perception associated with maps is predominantly the perception of form. Bowman (1968:10) states that basic elements in the perception of form are point, line, shape, colour value and texture. The perception of form in maps centres around the figure-ground relationship. This relationship which has been discussed in 2:34 is enhanced by contrasts in colour hue and brightness, shape, size and texture. The Gestalt laws of organisation : area, proximity, closedness, symmetry and good continuation, offer bases for predicting which shapes will become "figures". Cognition also aids in the perception of the figure-ground relationship because understanding is necessary in the successful decoding of map signs (Wood, 1968:57).

> "Perception is not a passive registration of incoming signals, but an active adaption of the visual process by activating certain channels between cortex and retina, and by blocking up other routes. The whole process functions like a selective filter which is adjusted to the expectations on hand and provides data for a first checking. This filtering procedure is of both a physiological and mental nature and may be optimised by training."
>
> (Hempius, Hass amd Vink, 1967)

Therefore, determination of the figure-ground relationship depends on the map user's attributes, interests, education and the way in which he searches a map. The manner in which map users' search maps has been investigated by Bartz (1969, 1970) and Beller (1972). They concluded that searching maps is similar to searching other graphic displays since the map user investigates the map in an irregular pattern consisting of random fixations over the map. Search time reading maps is influenced by the clarity of the figure-ground relationship. If it is not clear,the map user's search time will be increased. Most of the search time with maps is spent on rejecting irrelevant information. If the map user has some understanding of the signs he is searching for on the map then his search time will be reduced. This understanding will be aided by an understanding of the conventionality of colours used on topographic maps.

Other psychophysical studies which assist in understanding visual perception include: Hochberg and Brooks (1962) who concluded that letters are easier to see when they form "holes" rather than "things"; Hochberg (1962) who established that edges of objects are elements of shape; Smith (1958) who concluded that judgments of distance of objects vary independently of the judged size of portrayed objects; and Greenberg (1971) who concluded that the underestimation of map symbols was worst when the image-background brightness level is intense, the image-to-background contrast ratio is great, when environmental illumination is very low or very high,and in which visual accommodation is imperfect, blurred or oversaturated.

The role of colour in visual perception has been mentioned in Chapter 2.34. This influential factor in the perception of maps is often the basis for the figure-ground relationship. Colours help us distinguish things. Certain colours define patterns more clearly than others. In his list of legibility combinations, Sargent (1964:59) lists the best combinations as black on yellow and green on white and the worst as green on red and red on green. Therefore, if careful selection of colour combinations on maps is not made, the map user cannot be expected to read the map accurately. Conover (1959) concludes that the limit of absolute discrimination for colours ranges from five to twelve depending on the viewing conditions. Colour, when combined with some other perceptual attribute, is more effective than colour alone. Anderson and Fitts (1958) found that colour plus shape proved effective in visual perception. Newman and Davis (1962) found that when colour was added to symbols that the size of the symbol code could be reduced and that the use of two or three non-redundant (contrasting) colours improved both speed and accuracy in searching and decoding tasks.

Visual perception will be more effective if the map user can perceive a visual hierarchy of information on the map. Muzylev (1946) demonstrated the dependence of visual acuity on the intensity of the illumination during reading. McCormick (1970:62-63) saw this illumination contrast as a basic determinant of the figure-ground relationship. Robinson and Petchenik (1976: 80) synthesised the factors in the sequence of visual processing necessary to produce a visual hierarchy as the graphic characteristics of the display (contrast, colour saturation and complexity), separability and memorability of the display. However the map is perceived, it is perceived as a whole. Therefore, no elements of the map can be considered in isolation.

Map-reading ability

Children's ability to read maps is a skill to be cultivated as they grow intellectually. This view differs from that of Savage and Bacon (1969) who concluded that first-grade children could learn about maps at an abstract level. However, it is supported by Sabaroff (1959:184) who argued that map skills involve more than matching sign and referent. Only when the child sees a sign and conjures up a mental image is he acquiring meaning from map signs. Whipple and James (1947) agree that the child needs to understand the map before he can envisage the reality it represents.

Substantiation of statements concerning the map-reading abilities of children is found in the form of logical hypothetical statements, and in quantitative research. Rushdoony (1968:214-215) summarised the research into children's map-reading abilities up until the late 1960s. He concluded that there tends to be a grade-by-grade progression in the children's ability to read maps; children's errors or misconceptions are related to the lack of any systematic teaching of map reading; and there is no best method for teaching map-reading.

Quantitative research by Snyder, Feldman and La Rossa, (1975), based on Piagetian ideas of cognitive development, resulted in a six-level sequence of children's development in spatial reasoning derived from map drawing. This sequence indicated a progression in spatial reasoning from no spatial correspondence of objects around age four years, through the development of of partial projective and Euclidean co-ordinations to the development of an abstract plan with metric co-ordinates around ages twelve to fifteen years.

What skills constitute map-reading ability? Since the early 1950s researchers, largely in America, have sought to clarify this aspect of spatial ability and to develop programs of map skills to cultivate these skills. Table 2 is a synthesis of the "essential" skills required by children to be able to read maps. Assuming that the skills presented in Table 2 are representative of those skills required for map-reading, one can conclude that the most important ones are symbolisation, direction, scale, location and orientation. These five skills could form the base of a hierarchy of map skills as illustrated in Figure 13. Figure 13 is constructed on the basis that map language and symbolisation are sufficiently similar as to be grouped together, as are location and relative location.

Table 2 SUMMARY OF ESSENTIAL SKILLS NEEDED FOR MAP-READING

SKILL	AUTHOR									
	Kohn (1953)	Thralls (1958)	Warman (1959)	Sabaroff (1961)	Davies (1962)	Farrar (1963)	Kennamer (1963)	Hanna *et al.* (1966)	Stringer (1976)	Askov & Kam (1974)
•Orientation	*			*	*	*	*	*	*	
•Direction	*		*	*	*	*	*	*	*	*
•Scale	*		*		*	*	*	*	*	*
•Distance	*				*	*	*			
•Location	*			*	*	*	*	*	*	*
•Relative Location	*			*	*		*	*		
•Distribution					*			*		
•Symbolisation	*	*	*	*	*	*	*	*	*	*
•Map Comparison	*						*			
•Inferencing	*	*				*	*		*	
•Map Language		*			*	*				
•Map Drawing		*			*	*		*	*	
•Projection			*		*	*	*	*		
•Legend			*				*			
•Map Titles			*							
•Observe Landscape					*		*	*		
•Globe as Model				*	*			*		

* = Referenced by author (after Wilson, 1979)

LEVEL	MAP SKILLS			RELATIVE IMPORTANCE
4	Distribution	Use of Title	Map Comparison	Less Basic ↑
3	Globe as a Model	Observing Landscape		
2	Map Drawing	Distance	Inferencing	
		Projection		
1	Symbolisation	Direction	Orientation	
	Location	Scale		Basic

Fig. 13 A HIERARCHY OF MAP SKILLS

This hierarchy could form the basis of a map skills program to develop the ability of map-reading. Although this hierarchy seems respectable based on the conclusions of the notable researchers in Table 2, the skills of inferencing and the use of a title seem misplaced. Rhys (1972) in his study of the development of children's logical thinking concluded that the reasoning necessary for inferencing was not developed until 15+ years of age. Children should understand distance long before they are fifteen years old. Therefore, inferencing would be more appropriate on the highest level of the hierarchy. Equally so, title does not appear to be as complicated a skill as map comparison or distribution. It should, therefore, move to level two or three on the hierarchy. The concept of a map is closely linked with map-reading ability since the map user cannot understand what a map is until he develops the skills to utilise it. Imperatore (1970:174) states that concepts are associated with mental images and ideas; they are shown to be part of a mental categorisation system into which a person files the phenomena he perceives; they are associated with semantics and word analysis; they are viewed as word labels for ideas;and they are involved in human thought processes. Concepts may be organised in a hierarchy depending on their degree of generality and organisational nature. A hierarchy of concepts arranged from specific concepts to general concepts will range from substantive concepts, through high-order concepts to organising concepts. Therefore, mountain is a substantive concept while location is an organising concept. The concept "map" is located towards the substantive end of the hierarchy of concepts. Since all concepts have identifiable attributes, what are the attributes of the map concept? In 2.10 of this chapter, the map was defined as being a representation of some area drawn on a two-dimensional surface. The attributes of arrangement, proportion, perspective (orthogonal view) and symbolisation as defined earlier by Snyder and Feldman (1975) are satisfactory additional ones to representation as the general attributes of a map. Therefore, a map has the attributes of a representation of an area; an arrangement which corresponds to the spatial arrangement of that area; objects which are represented proportionally by cartographic signs; a viewpoint which is orthogonal,and a system of signs by which the information is coded on the map.

Age

The influence of age on the map user deserves consideration because many developmentalists in the field of psychology lay emphasis on it when they state their findings. Ever since Piaget proposed his theory of stages of development and attached ages to these stages, e.g. twelve years for the formal operational stage, many developmentalists have done likewise. Often the purpose for doing so has been to compare the resultant ages either explicitly or implicitly with Piagetian stage ages. Snyder and Feldman (1975), attached estimated ages to each of their six levels of spatial reasoning as revealed in map drawing, e.g. Level 5 - mastery of distances and proportions (about 10-12 years). Rhys (1972), in his study of the development of logical thinking in geography students, identified a four-stage sequence and linked ages to each stage, e.g. 15+ years for stage four (hypothetico-deductive reasoning). Towler and Nelson (1968) investigated the development of the concept of scale. They concluded that although the concept of scale begins to appear at age ten or eleven years, there are few instances of full understanding before twelve years. Towler (1971) and Towler and Nelson (1967), on investigating children's development of spatial reference systems, concluded that Piaget's age of nine to ten for achievement of a co-ordinated reference system is two to three years too young.

One of the most explicit examples of research linking age with achievement in mapping was the International Geographical Union report by Brown et al. (1959) entitled An investigation into the optimum age at which different types of map questions may best be set to pupils in the teaching of geography. This study investigated how over 1000 pupils understood map concepts of scale, distance, grid reference, conventional signs and settlement problems. The results of this study were analysed in detail according to the age of the pupils. For example, for pupils aged eight years the findings were that all children found it easiest to answer the question on conventional signs. In this question there was a marked superiority of boys over girls (which was not evident for the other questions). At least two thirds of the pupils experienced difficulty with the direction question. The measurement of scale presented difficulties to most pupils. Similar results were reported for each age level up to and including fifteen years.

Age and education are generally related. According to Balogun

> "The two connote some form of experience about the world generally, some wisdom and reasonableness. They therefore involve the ability to realise that the map and its symbols are just a representation of something real. They also connote literacy and ability to concentrate and perceive better."
> (Balogun, 1978:79-80)

Vernon (1970) concluded that perception of form becomes increasingly more accurate and rapid with increasing age.

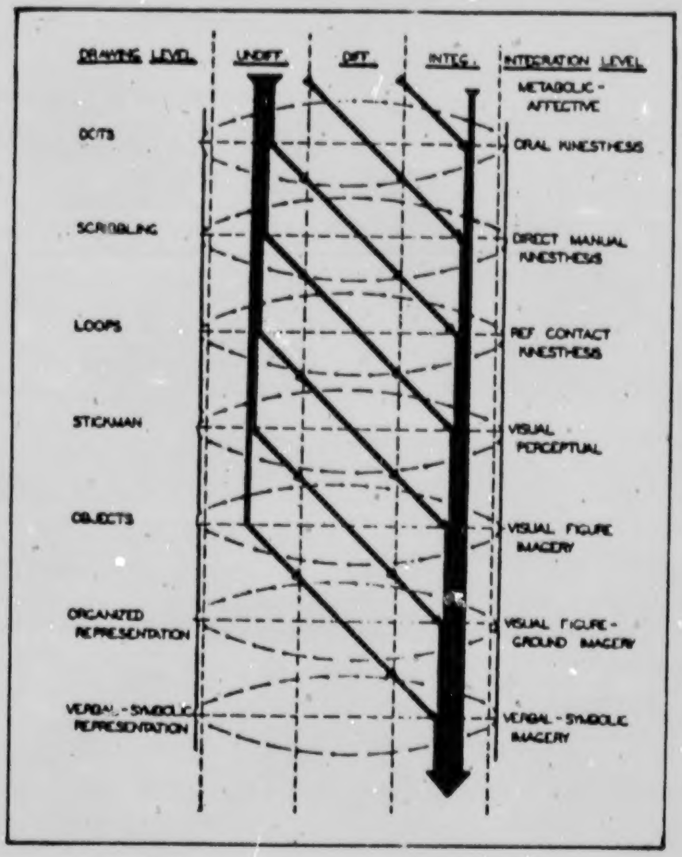
The sex of the map user has often been linked with his or her age. International studies of sex differences in spatial abilities, as summarised by Maccoby and Jacklin (1974), suggest that these differences are inconsistent until age ten years, then males outscore females. Australian studies of sex differences in spatial ability tend to be divided. Byrt (1976), Clements and Wattanawaha (1977) and Collins (1976) have found sex differences in spatial abilities in favour of males. To match these findings, Mackay (1976), Newman (1976) and Weber (1978), found no significant differences or a slight favouring of females. In the field of mapping, this author found no significant difference in map competence between boys and girls aged ten through fifteen years (Gerber, 1977:105-106).

Drawing Ability

Children's performance in cartographic language focuses on their ability to draw maps. These graphic displays present a representation of the spatial characteristics of an area from a vertical position. The child can make a drawing of the same area. This drawing will usually arrange objects as they occur in the area. It will represent the objects in some form (usually pictorially) in proportion to their actual existence. Unlike a map, the drawing will probably be from a horizontal viewpoint. Eng (1954;187-188) has stated that children's drawings indicate:(a) how their powers of observation and analysis develop;(b) the growth in their capacity for synthesis, thinking and power of judgment;(c) the progression in their imagination;(d) their reflections of their feelings and interests; (e) the development of their sense of form;and (f) their growth from meaningless to meaningful movement. The development of a sense of form which Eng stresses is part of the development of visual perception, particularly the perception of form.

The link between perception and drawing has been elaborated and developed by Bell (1952;386) who declared that the level of drawing is the product of the particular perceptual level of development of the child and that the exercise of drawing operates as an experiment for the child in the integration of perceptual processes into the child's total functioning.

Bell's model of the levels in drawing and perceptual development (Figure 14) is a basic sequence which develops in a spiral fashion from undifferentiated dots and oral kinesthesis through to verbal-symbolic imagery represented on drawings. Integration occurs at each horizontal plane before the child's drawing development progresses up the spiral. Bell makes it quite clear that at each stage of development there are field characteristics, e.g. culture, social/family background, economic circumstances and geographical setting, which will modify these processes.


DRAWING LEVEL
UNDIFF.
DIFF.
INTEG.
INTEGRATION LEVEL
METABOLIC-AFFECTIVE
DOTS
ORAL KINESTHESIS
SCRIBBLING
DIRECT MANUAL KINESTHESIS
LOOPS
REF CONTACT KINESTHESIS
STICKMAN
VISUAL PERCEPTUAL
OBJECTS
VISUAL FIGURE IMAGERY
ORGANIZED REPRESENTATION
VISUAL FIGURE-GROUND IMAGERY
VERBAL-SYMBOLIC REPRESENTATION
VERBAL-SYMBOLIC IMAGERY

(after Bell, 1952)

Fig.14 LEVELS IN DRAWING AND PERCEPTUAL DEVELOPMENT

Eisner (1967) has synthesised the range of views on the development of child art. He concludes that seven notable views have been advanced. They are:

i) Arnheim's view (1974) which emphasises the growth of perception through a process of perceptual differentiation. This Gestaltist view states that perceptual differentiation is accompanied by increased differentiation of graphic forms created by children as they present two-dimensional structural representations for the objects perceived. Children draw what they see, not what they know.

ii) Alschuler and Hattwick's view (1947) which emphasises the personality traits of children as shown in their drawings. As children mature they move from a concern for self-expression in emotional terms in their drawings to a concern with literal representation. The space used in the drawing reflects the child's use of his environment.

iii) Goodenough (1924) and Harris (1963) both stress that drawing is indicative of concept formation and general intelligence. Therefore, the act of drawing is a cognitive activity and is affected by the abilities which affect any performance.

iv) Meier (1933) emphasises that art ability is a result of an interaction between genetic traits and environmental conditions. The six factors which affect art aptitude are classed as either a) heredity factors : manual skill, energy-perseverance and intelligence , or(b) nurtured factors: perceptual ability, creative imagination and aesthetic judgment.

v) Lowenfeld's view (1957) focuses on the unfolding character of children's developmental stages - the six stages ranged from scribbling to the adolescence crisis. Unlike the Gestaltists, Lowenfeld emphasised the environmental and social aspects of artistic behaviour.

vi) Read (1945) views art as the general process by which man achieves harmony between his internal world and the social order in which he lives. Therefore, the child's personality and a range of pre-mordial images or archetypes which are left in the human mind through evolution of the human race, influence artistic performance, e.g. the circle, the star and the mandala.

vii) McFee (1961) has proposed a perception - delineation theory which states that the child's drawing performance is affected by readiness, the child's ability to handle information, the work situation and the child's delineation skills. Therefore, artistic behaviour is a function of multiple causality.

The above theories provide some links or similarities between drawing and mapping. Arnheim's Gestaltist approach of progressive perceptual differentiation relates to the progressive differentiation of space evident in the maps drawn by children of different ability levels. Harris' approach which links drawing with cognition is equally applicable to maps because the signs representing phenomena on maps require conceptualisation if they are to be decoded meaningfully. There is a definite link with McFee's view because children's drawing of maps is influenced by their ability to encode cartographic information. Since drawing and mapping are both spatially-oriented tasks they are likely to have similar cognitive and creative characteristics.

Map Experience

Experience with maps is a very general term which includes not only actual map reading experiences but those experiences which may enhance map reading.

Experience in map interpretation affects the amount and quality of information retrieved from a map (Balogun 1978:79). An experienced map user understands that map signs are not usually drawn to scale and he knows what conventional signs mean without consulting a legend. He also understands which are the "figures" on thematic maps and that they are relatively accurately mapped. In addition, the experienced map user appreciates that because the map is a representation of some area drawn at a greatly reduced size, a selection of phenomena has been made during the generalisation process.

The formation and development of spatial images are largely products of the individual's experience with his environment (Vanselow, 1974:11). Vanselow (1973:4) also stresses the importance of experiencing the environment directly (at first hand) or indirectly (from books, television, maps, films and conversations). Much of the environment will be experienced directly, by driving in a motor vehicle, on horseback, on a bicycle or by walking, As a result

> "......direct experience of the environment usually occurs at ground level, giving the individual a horizontal perspective." (Vanselow, 1974:11)

This deficiency becomes evident when children are asked to draw maps. Studies have shown that most of these maps are either sequential or spatial in nature (Appleyard, 1970; Rand, 1969 and Shemyakin, 1962). In sequential maps, areas were connected by roads which were the dominant aspect on the map. Spatial maps consisted of scattered elements - buildings, landmarks and districts. Sequential maps were created by children with horizontal perspectives whilst spatial maps were created from the orthogonal viewpoint. As more and more individuals fly around the world, this notion of a dominant horizontal perspective may be broken down.

Research into maps and pictures presents further evidence of the influence of experience. Dale (1971), while investigating seven to eleven year old children in relation to their use of maps and aerial photographs, found that those children with the clearest spatial sense were those who roamed around their neighbourhood. They had the best spatial orientation. Their orientation was better than that of children who travelled around by car.

The evidence relating to pictures and experience is based on the findings by Kennedy (1974) and Pick (1976) who found that uneducated "primitives" were usually able to identify objects in pictures, but did not understand relationships between objects. However, "primitives" exposed to education could deal with pictorially represented information. Therefore, Pick concluded that some experience with pictures is required to learn the rules of picture reading.

Attitudes to maps

> "When planning a map, it is not particularly difficult to specify precisely and in detail the characteristics of each of the component graphic elements considered in isolation. But the viewer's first reaction to the map, under most conditions of use, is not to these individual elements of the display, but rather to the map as a whole."
> (Petchenik, 1974:63)

Petchenik's statement highlights a basic difference between many cartographers and map users - cartographers take great care with the individual elements of the map whereas many map users are quite subjective and are concerned with the overall appearance of the map. Cartographic concern for the total appearance of maps has been limited even though Robinson touched on the subject in 1952.

The value of the overall "look" of maps is that it increases the opportunity for objective, perceptive analysis or criticism of the map. If the cartographer is able to state the visual goals of his map, then he or any map user can compare the design intent with the mapped outcome (Petchenik, 1974:64). This approach should produce a more thorough analysis of maps.

What factors affect the look of a map? Petchenik (1974:64-65) identifies five important factors:

i) the visual character of the elements considered,

ii) the perceived relationships among the elements (Context and balance are more important qualitative and spatial considerations than the character of any one map sign or class of map signs.),

iii) the nature of the content,

iv) the character of the map production process

(Woodward (1970) showed that the look of American commercial maps was influenced by the reproduction technique of cerotyping.), and

v) various characteristics of the people who organised and controlled the technology.

Using the semantic differential technique, Petchenik (1974:68-70) has developed a hierarchy of descriptive aspects of maps. This hierarchy contains:

i) Physical measurements, e.g. Xcm. by Ycm. in size; 75.0per cent of the area is covered with .0086g. of #212Pcm black ink, which are measured by technical means.

ii) Sensations about which most map users would agree, e.g. contrast between line weights, variations in colour hue and value.

iii) Specific and general impressions are emotional aesthetic feelings of the map user to the map. Specific impressions which are analogous to physical sensations, such as height and texture, include descriptors such as "crowded", "rough" and "tranquil". General impressions are global, conversational terms normally used in atlas reviews, e.g. "find attractive", "like" and "clear", which tell the cartographer very little about what is producing the response.

iv) Emotional and idiosyncratic associations which are called to the mind by the appearance of the map, e.g. "This map reminds me of a cold wintery day.".

The semantic differential technique lends itself best to measuring specific, subjective impressions. Petchenik (1974:69) concluded that five general map characteristics - spatial characteristics, texture, light, data quality impressions and emotional reactions - described by polar-word pairings can be used to describe the map look. For texture, for example, Petchenik has suggested the pairings of "hard-soft, coarse-fine, fragmented-coherent and rough-smooth". By the use of such a technique cartographers and researchers should be able to obtain a reasonable insight into the users' attitudes toward any variety of maps.

Home Environment

The individual's environment is an important contextual variable in his education. The Hadow Report on the Primary School in England (H.M.S.O., 1931: paragraph 48) declares that children who enter school "with the foundations of education .... well laid" and who, as they grow older, acquire "almost as much general knowledge in the home as..... in the school, and.... almost as much information about the world and its way through leisure hours ....as from formal lessons in the classroom". This has led the Plowden Committee to state that

> ".......educational policy should explicitly recognise the power of the environment upon the school upon the environment." (H.M.S.O., 1967:30)

Research and intuitive examples indicate the influence of the home environment on children's mapping ability. Blaut and Stea (1971) concluded that pre-school children from families of higher social standing have better basic map-reading ability. Dale (1971), working with children aged seven through eleven years and their reactions to maps and aerial photographs, concluded that

> ".....the ability to read maps is related to spatial intelligence although patterns of social behaviour are also a key factor."
> (Dale, 1971:177)

Wilson (1978) illustrated the influence of parental occupation on mapping ability with the example of a ten-year old child who displayed an exceptional ability to draw maps. This child's father was a surveyor. She had lived and played with maps all her life.

The best research evidence concerning the home environment and education is sociological study in education. The 1964 National Survey of Parental Attitudes and Circumstances Related to School and Pupil Characteristics which forms the basis of the report of the Central Advisory Council for Education in England (1967) is one such study. The main purpose of the survey was "to relate what we could learn about home and school to the attainment of the children." Of the three major survey categories - parental attitudes, home circumstances and state of the school - the first two are important and relevant to the home environment and mapping. Parental attitudes relevant to mapping **included literacy in the home**, time parents spent with their children,and parents' links with the school. Home circumstances included physical attributes of the home, parental occupation and parental education. The survey revealed that parental attitudes explained 28 per cent of the children's educational performance, home circumstances 20 per cent, state of the school 17 percent, with 35 per cent of the performance unexplained. This conclusion of the importance of the home and parental attitudes verifies earlier conclusions drawn by Fraser (1957) and Floud, Halsey and Martin (1956).

The range of variables of the map user detailed above indicate the difficulty of controlling the map user in the cartographic communication process. This range is by no means exhaustive. Wood (1968) suggests the inclusion of a variable entitled imagination. Balogun (1978) indicates that map users' interests should be considered. The challenge is for the cartographer to consider these when designing a map. Consideration of the range of map user variables is necessary if the cartographer wishes to answer the following questions:

i) Should the signs be pictorial and colourful or arbitrary and not necessarily colourful?

ii) Does each sign presented in the legend make sense to the map user?

iii) Are the colour combinations conducive to effective interpretation and not disturbing to the eye?

iv) Who are the potential map users?

Summary. Cartographic communication uses maps as the vehicle for communication. The cartographic communication process is a convenient means for systematic analysis of the interaction between cartographers, maps, and map users. Models developed over the last decade by Balogun, Bosowski, Kolacny, Muehrcke, Ratajski and Robinson and Petchenik, present a range of interpretations of this process. Information theory does not provide a suitable base for understanding the cartographic communication process because of the non-linear nature of maps and the lack of definite fixed meanings for particular signs. The cartographer, in creating maps, should consider map users' perceptions of signs, the organisation of signs (especially the figure-ground relationship), the process of generalisation, the use of colour on map signs and the positioning of names on maps. The map user's role in the cartographic communication process is influenced by a range of individual and environmental factors.

2.40 Cartographic language.

The cartographic communication process can only be successful when the cartographer and the map user are on similar cartographic wavelengths. Sections 2.34 and 2.35 have indicated the variety of influences on these key people in cartographic communication. It is generally accepted that the medium for cartographic communication is the map. If the cartographic message is to be carefully encoded and equally successfully decoded, then both cartographer and map user should be competent in the language used in the communication - cartographic language. Language, here, is used in the casual sense to mean anything communicated by human beings, from thought conveyed by words or mathematical symbols to emotions conveyed by gestures (Robinson and Petchenik, 1976:44). Therefore, the means by which maps are encoded and decoded (cartographic signs) constitute cartographic language.

What is being suggested is a semiotic approach to cartographic language. Semiology, the science of signs, aims to take in any system of signs whatever their substance and limits. These constitute, if not languages, at least systems of signification (Barthes, 1967:9). Ratajski (1971:138) sees the map as "a system of conventional signs ideographs" (This is at least true for topographic maps). Within such a system it is possible to perform analytical operations leading from meanings towards elements and synthetical operations leading from elements to meanings.

> "This interpretation of the conception of a system equals the conception of a code." (Ratajski, 1971:138)

Greniewski (1968:36) suggests that the categories of the cartographic code include:(a) informative elements and (b) information. Informative elements which denote syntactic features include: singular terms (information regarding the position of a given place using a reference system such as parallels of latitude and meridians of longitude), one-argument predicates (signs of various graphic shapes - circles or triangles) and relations of comparison which may be external or internal. Internal relations include the relative location of places on a map. External relations may be of three types: (i) a relation of denotation where the mutual positions of two places are proportionally the same on the map; (ii) a relation of predication, e.g. when a small black rectangle denotes a factory or a circle denotes a town; and(iii) a relation of reflection which determines the ratio of the concept of reality created by using the map to that reality. Information includes "simple information" and maps (the vehicles for communicating cartographic information).

From this scheme one can recognise three overlapping divisions of semiology : syntactics, semantics and pragmatics (Cherry, 1957). Syntactics focus on the rules relating to the internal structure of the system of signs. They determine syntax:

> ".....a collection of the rules of construction, and consequently, a collection of the rules of map-reading, or, in other words, syntax of the code of a map." (Ratajski, 1971:139)

Ratajski sees this syntax of the cartographic code as consisting of : the rules of construction; the rules of decoding orientation and position; and elements derived from providing meaning to formal expressions. Meaning to formal expressions results from either conventions (e.g. conventions of orientation - north to the top of the map , and conventions of meaning of signs - a small circle denotes a city) or from the character of psychophysical processes (e.g. problems of shape, size and colour).

Semantics concerns the meaning of signs or the relationship between signs and the concepts they represent. Board (1973:230) stresses that the semantics of map language concern the ways in which the signs used represent geographical concepts not the real world itself. One cannot argue that cartographic signs are like letters of the alphabet that always have the same meaning. The rule for constructing three-dimensional forms by isolines states that lines such as contour lines, must not cross or join one another and must close except when they intersect with the margin of the map. Board (1973:230) states that patterns, colours or shapes represent similar concepts, but the same concept may be represented by more than one type of sign, e.g. altitude may be represented by spot heights, contour lines and hypsometric tints. Imhof's rule of "the higher the lighter" or Lehman's alternative "the higher the darker" are semantic aspects of cartographic language. The concepts of physical form of the surface of the Earth are more generally accepted than those in the socio-economic sphere (Board, 1973:230). This may be the reason that topographic map signs are standardised whereas the thematic signs representing socio-economic phenomena are not. Harvey (1969:376) claims that this argument extends to the choice of appropriate geometry in which to portray socio-economic concepts such as population and social class.

The study of pragmatics in regard to cartographic language involves its relation to the people who use it. Considerable emphasis has been placed on cartographic communication in this study. On this basis, the people who would come under scrutiny in a study of pragmatics would be the cartographer and the map user. Chapters 2.34 and 2.35 are elaborations of the responsibilities and goals of the cartographer and the nature of some of the important characteristics of the map user. Board (1973: 230-231) indicates the need to synthesise the research in this area so that a meaningful understanding of the pragmatics of cartographic language can be obtained. This study contributes to such an understanding by seeking to ascertain which of the map design and map user variables in Chapters 2.34 and 2.35 contribute to the individual's development of competence and performance in cartographic language.

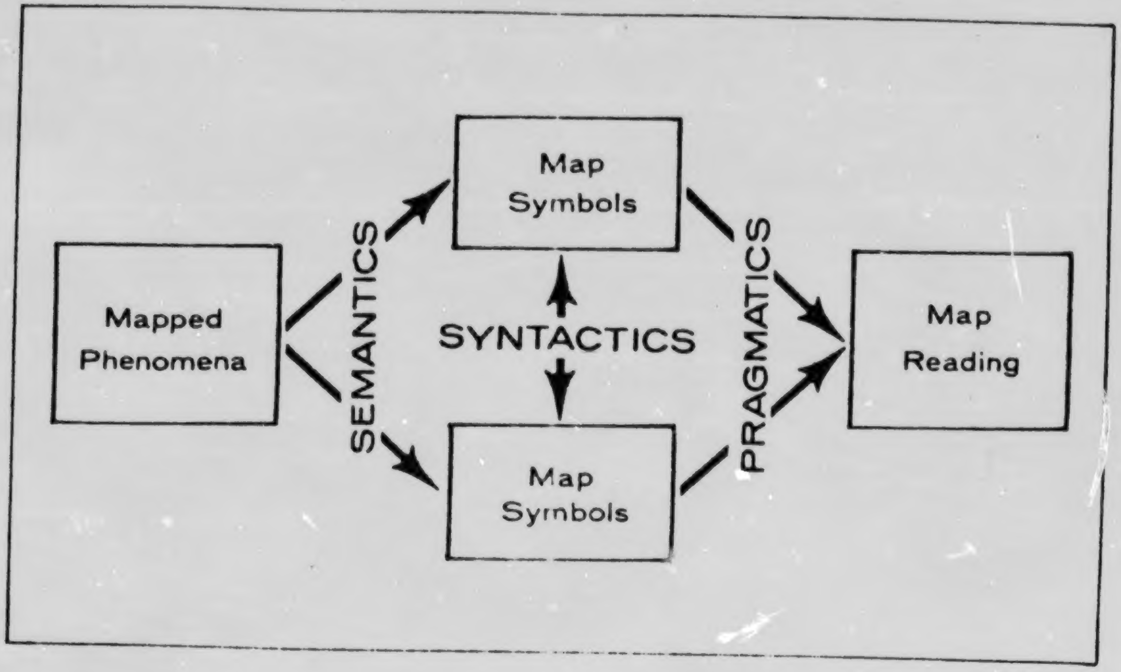
The semiotic viewpoint of cartographic language refers to three major divisions of cartographic processing:

i) the study of the relation of map symbols to their referents,

ii) the study of the relation of map symbols to one another, and

iii) the study of the relation of map symbols to the people who use them - the cartographers and the map users (Muehrcke, 1972:35).

The relationship between the three strands of the semiotic viewpoint has been organised into a graphic structure by Muehrcke based on the theoretical statements of Morris (1938). This structure is presented in Figure 15. As indicated in Chapter 1, this study, whilst relating cartographic signs to one another and to their referents, focuses on the map user and his development of cartographic language.


Mapped Phenomena
SEMANTICS
Map Symbols
SYNTACTICS
Map Symbols
PRAGMATICS
Map Reading

(after Morris, 1938 and Muehrcke, 1972)

Fig. 15 STRUCTURE OF THE SEMIOTIC VIEWPOINT AS APPLIED TO CARTOGRAPHY

Most of the writing on cartographic language is about cartographic symbols. However, since orthophotomaps can now be classified as a legitimate map form, the signs on it may be classified as cartographic signs. Since photographs are representations of reality, the photographic details on an orthophotomap may be classified as a range of cartographic representations, just as abstract symbols are another form of cartographic representation. Therefore, one may argue that cartographic signs do not equal cartographic symbols. Also, it may be argued that cartographic signals do not equal cartographic symbols. The main thrust of this difference in terminology is to propose that cartographic signals differ from cartographic symbols, but that both are cartographic signs. Therefore, in general terms it is more inclusive to speak of cartographic signs.

The basis for the distinction between signal and symbol is Piaget's distinction between operative and figurative thinking (Furth, 1968: chapter 5). Operative thinking is that aspect of intelligence which transforms a particular reality state and leads to constructs such as numbers, classes and other logical thoughts. This type of thinking is closely related to the equilibration process, the process by which the child copes with new learning situations and fits them into his schemes via the processes of assimilation or accommodation. The process of assimilation implies some form of comprehension directly related to the structuring or transforming of knowing whilst accommodation refers to the application of an active scheme to a given event. Therefore, if a child sees an object that has a wooden or bone handle and a long metal blade attached to it, he will probably say that it looks like a knife. Therefore, the child has assimilated his perception of the object in respect to an established conceptual system of knives. If the child encounters an unusual knife belonging to a primitive society, a state of disequilibrium could be established because the object does not conform to the child's present perceptions about knives. If this new type of knife is to be included in the child's schemes then the child must reshape and reorganise his conceptual structure of knives. This process of accommodation is basic as the child broadens his or her spatial identity with increased intellectual development because the child will come into contact with many objects which will not be included in his or her present conceptual structures. Operative thinking is sufficiently broad to include action knowledge from sensorimotor through formal operational intelligence.

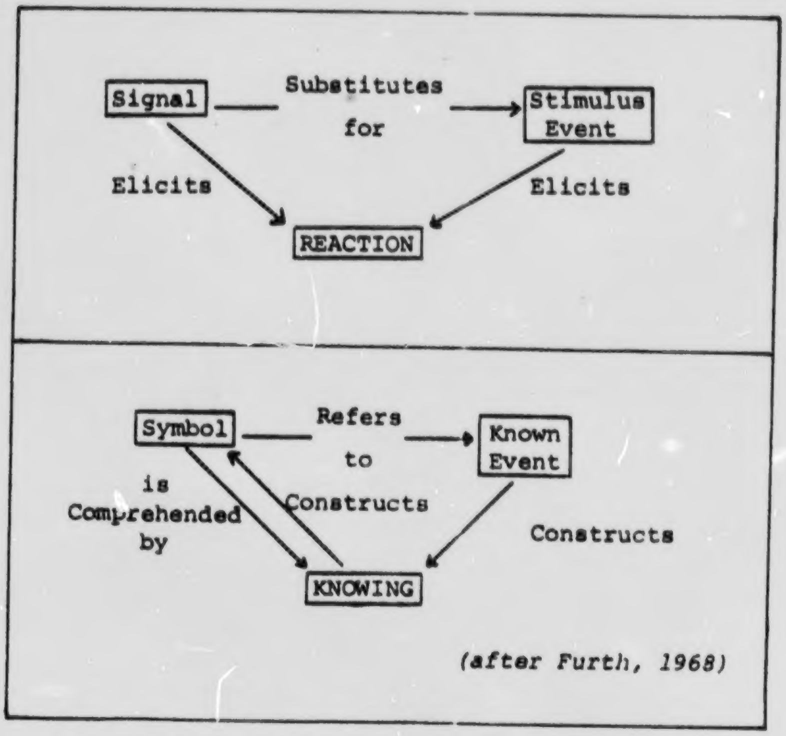
Figurative thinking occurs when the knowledge bearing of the configuration of an event has sensorial content and is perceptual. It indicates thinking in the present static sense. Therefore, a three-year old child can structure the seen event into an object that he knows to exist (i.e. an object of perception). However, as Furth (1968:86) stresses, only within an operative framework is the figurative aspect of perceptual objective knowledge conceivable. It should be noted also that figurative thinking goes beyond perception to include some ability to represent what is known (a symbolic function).

It is now possible to examine the ways of representing what is known, which focuses on the notion of signs.

A sign may be defined as

> "........any thing or event within a behavioural situation that provides some knowledge to an organism about another thing or event; on the basis of this knowledge the organism behaves adaptively towards that other event."
> (Furth, 1968:86)

Signs may be divided into two broad classes - signals and symbols. As Figure 16 indicates, signals are signs that are characterised by external form (Werner and Kaplan, 1963:41). Signals function as a stimulus substitute which elicits a behavioural reaction similar to the original stimulus. This signal-stimulus relation is undifferentiated. Therefore, the development of a massive cloud formation characterised by an anvil near its top is a signal of an impending thunderstorm.


Signal
Substitutes for
Stimulus Event
Elicits
Elicits
REACTION
Symbol
Refers to
Known Event
is Comprehended by
Constructs
Constructs
KNOWING

(after Furth, 1968)

Fig.16 DIFFERENCES BETWEEN SIGNALS AND SYMBOLS

Symbols, on the other hand, are signs that are produced or reproduced by the organism and they directly follow from or lead to an internal action of knowing. Therefore, in regard to the real event, the symbol is related because it is indirect and mediated by knowing. There are two reciprocal relations of active constructions: the symbol refers directly to the knowing of an event because it is developed as a representation by the same scheme of knowing that was operative in constructing the event in the first place.

Traffic signs illustrate the distinction between signals and symbols. A road sign is a signal in that a fixed one-to-one relationship exists between the sign and its meaning. Consequently, a traffic sign for a pedestrian crossing has a clear, singular meaning. Traffic signs and other signals serve as stimuli and expect a predicted reaction. Any further relationship between the signal,and its meaning is usually arbitrary. If an individual wishes to ascribe other than the desired meaning to the signal he is involved in symbolic representation. Signal behaviour at traffic lights is characterised by sensorimotor reactions at a sub-human level, e.g. stepping off the kerb at a change of lights - to either red or green. Consequently, the interdependence of the concrete situation and meaning characterises signal behaviour.

Symbols represent an idea and demand an insight and understanding which is not a requisite for the mechanical reaction to a signal. They possess historicity (i.e. the symbol is inseparable from its embeddedness in time) and their meaning permeates the physical vehicle which is its carrier. Traffic lights are symbols as they are used by traffic controllers, i.e. traffic lights use the colours of red, amber and green which have become international symbols for controlling vehicular and pedestrian movements. Therefore, the symbol has a cognitive function - a representation directed toward knowledge. This view is advanced by Thass-Thienemann:

> "The symbol addresses man who wants to see, observe, contemplate, and asks not for the cause, but for the meaning of a phenomenon. The symbol is the tool for thinking. It does not simply react to the physical reality, but presents its meaning and demands understanding. It creates an intermediary sphere between the objective physical and the subjective reality. Language is the most elaborate realisation of this intermediary sphere."
> (Thass-Thienemann, 1973:22)

When this idea of signs consisting of signals and symbols is applied to cartographic language, it permits the inclusion of many of the signs on orthophotomaps as signals and the usual range of topographic and thematic signs as symbols. Most of the signs on orthophotomaps are signals because they are characterised by external form, i.e. any meaning that is acquired regarding the sign is derived from the look of the sign and not from any conceptual understanding. For example, the aerial representation of a clump of trees on an orthophotomap produces a textured effect which looks exactly like trees seen from above. There is a definite one-to-one correspondence, so that the perceiver need only to be able to identify the look of a clump of trees to make sense of this signal on an orthophotomap.

The example of trees may be extended to symbols by inserting the expectation of the perceiver deriving meaning from the symbol via understanding the substantive concept of "trees". If this concept is sufficiently developed it will encompass the different sub-divisions of trees normally encountered in the legend of topographic maps. Therefore, the symbol for a tree, however it is drawn, will provide a location on the map (and possibly areal extent), but the remainder of the meaning of that symbol rests in the perceiver's mind depending on his or her understanding of the concept "trees".

What bases exist for reference in the construction of cartographic signals and symbols? Based on the definition of signals above and the acknowledgment of the orthophotomap as a form of mapping, cartographic signals as portrayed on orthophotomaps contain the characteristics of tone, colour, texture, shape, shadow, size and pattern. Tonal variations occur because of differences in the reflective qualities of objects. Tone, often described in terms such as light, medium and dark, is one basis for identification of signals. Moisture causes tone to be darker and marshland tends to be darker than the surrounding areas (Robinson and Sale, 1969:80). The use of colour enhances the signal since many objects, e.g. ploughed fields, fields under growing crops and fields of ripened grain, can be identified by colour alone. Texture (the "smoothness" or "roughness" of features) is used to describe changes in tone which are too small to be discernible. Grass produces a smooth texture whereas areas of forest have bumpy, coarse appearance. Shape (the general form) of features is the most reliable way of identifying signals (Robinson and Sale, 1969:80). Churches are often shaped in the form of a cross. Reafforested pine plantations and orchards have distinctive planting patterns. Areas of circular boom spray irrigation display clear circular shapes. Shadows facilitate an understanding of heights of landmarks if the time of day at which the photograph was taken is known. Size of features is important because it aids differentiation between objects of like shape. It is an indication of a measure of surface area or volume, e.g. a marsh area. Patterns of features (i.e. their orderly spatial arrangements) assist in interpretation because they differentiate types of land use as well as different densities of spatial occupance (Biddle, Milne and Shortle,1974; Lattman and Ray, 1965; Tyner, 1973). Cartographic signals suffer because the whole landscape is included. This causes embeddedness of features and obscuring of some features by other more dominant ones.

Cartographic symbols seldom represent a feature directly, but rather represent an attribute of that feature, e.g. a blue sinuous line represents a river, but on the map, the location of the river is emphasised. Such symbols present a number of difficulties. Muehrcke (1974a:17-18) concludes that these difficulties are:

i) the misinterpretation of cartographic symbols for the geographic reality they represent,

ii) a lack of communication between the cartographer and the map user (There is a danger that map users will supplement the information presented on the map with irrelevant and misleading additional information unless they dissociate from the task situation all purposes, past experiences and expectations.), and

iii) the misinterpretation elicited by cartographic symbols themselves, e.g. the relationship between symbols and their referents (The choice of circles, squares or triangles as geometric cartographic symbols is purely arbitrary. What does a square symbol for a city mean?) and cartographic colour schemes (Colours such as blue, green, brown and red have conventional meanings. If they are used in other ways, e.g. for shading on a political map or for thematic signs, the use of colour may be confusing to the map user.).

Cartographic symbols do not permit the use of negative statements (Biddle, Milne and Shortle, 1974: 103). The particular feature may exist on the map area, but during the process of generalisation, the cartographer removed it as he selected the cartographic information necessary for the purpose of the map.

Symbolic behaviour supposes organisation, interdependence and structures which translate the structures, patterns and relationships perceived in reality. What are the requirements of good, useful symbols? Chao (1968:210-227) indicates they include:

i) Simplicity. A system of symbols with the least amount of complexity to represent any given information will contain little distortion, ensure that every detail counts and that any variation in detail will produce a difference in the cartographic message. The simplicity of the cartographic symbols is constrained by the necessity for discrimination from other symbols of the system. For example, the symbols for streams are simple, but with sufficient discrimination to allow for immediate recognition of perennial streams (solid blue sinuous lines) from non-perennial streams (dotted blue sinuous lines).

ii) Elegance. This is important for symbols used for arousing attitudes and influencing action. The elegance of symbols is significant in the structure of a system of symbols, especially in relation to their parallelism and symmetry. The elegance of cartographic symbols relates to the use of line , point and area symbols. Area symbols, e.g. forest, marsh and woodland, display a degree of symmetry.

iii) Ease of production, reproduction, repetition and transmission. In the sciences almost all of the symbols used are two dimensional figures (words or two-variable graphs). Geographers make more use of ikonic figures based on models and colour schemes for their symbols. Green christmas tree symbols for coniferous forests, spheres of variable size for urban populations and triangles of variable size for mineral production are such ikonic symbols. However, three-dimensional symbols are usually viewed as two-dimensional symbols (Ekman and Junge, 1961) and two-dimensional symbols, e.g. contour lines, which demand a three-dimensional interpretation of a landscape cause younger map users considerable difficulty because of the embeddedness of the features.

iv) Size. Simple symbols kept to suitably small but discriminable sizes enable the map user to envisage the spatial relations on the map more clearly by eliminating too many steps of substitution and possible confusion of symbols for objects. Miller concluded that the size of a symbol may be significantly different from the information it represents (Miller, 1956:81-97). An appropriate size for a symbol is one that occupies a substantial part of the field of attention. Therefore, map symbols which are very small due to the reduction of the initial cartography are inadequate. This does not mean that all map symbols must be large, for an attribute of a smallish symbol is that it may be related to a number of other phenomena. Therefore, railway symbols should be of a suitable size to place them in perspective with embankments, cuttings and any nearby roads.

v) Balance between the number of symbols and the size of the symbol complexes. Generally, the larger the number of elementary symbols, the smaller the symbol complexes necessitated. For the cartographer and the map user, the balance between the variety of individual symbols and the size of the complexes should be considered from the viewpoint of learning and the long-term use. The optimum is likely to be between extremes. Since cartographers use a range of line , point and area symbols, one might expect a balance among these types. However, for Australian maps, approximately seventy-five per cent of all symbols used are line symbols (Williams, 1972:147).

vi) Clarity of the link between symbol and referent. An awareness of this relation is important so that the map user does not derive irrelevant meanings of symbols. The clarity of the link between symbol and referent in the wide range of ikonic cartographic symbols varies. The green christmas-tree symbols indicate a clearer link with coniferous forests than the green oval shapes do for eucalypt forests.

vii) Relevance of the structure of symbol complexes to the structure of their referents. The streets in some cities are numbered in a logical, orderly way. It is easy for a stranger to find his or her way around in these cities . The relevance of the structure of symbol complexes to the structure of their referents is evidenced by the cartographer's use of line symbols to represent linear referents (e.g. railways, fences and power transmission lines), point symbols for point-like referents (e.g. railway stations, windmills and wharves) and area symbols for areal representations (e.g. deserts, beaches and mangroves). This neat relationship varies according to the scale of a map. On a large scale map (e.g. 1:50,000) an urban area is shown as an areal symbol. When scale of the map is much smaller (e.g. 1:1,000,000) this same area becomes a point symbol.

viii) Discrimination between symbols. The exactness of the discrimination between symbols should be influenced by the conditions of use and the purpose of the map. The degree of discrimination should just exceed the degree of discrimination expected of the objects so that no information is lost in transmission. Generally the reception of cartographic symbols is accompanied by some distortion of meaning. Therefore, to provide for adequate discrimination, a good system of symbols should use a coarser discrimination than ideally possible, so that when decoded the symbols should account for all of the differences in the referents. Therefore, the range of vegetation symbols used on Australian topographic maps - dense forest tropical rain forest, medium forest, coniferous forest or pine plantation, scrub, marsh or swamp and mangroves - does not permit sufficient discrimination for geographers since there is no provision for semi-arid grasses or deciduous forests in the legend.

ix) Suitability of operational synonyms. Where symbols are used to transmit information from one person to another, they are understood more easily when each symbol is presented synonymously in various sensuous forms, e.g. visually and verbally. Therefore. a long sinuous body of water which has a source and a mouth and a longitudinal profile may be symbolised as a word "river" or a blue wiggly line.

x) Universality. A language will not become widely used if its signs are not common to the users. The symbols in music are good universal examples. The standardisation of cartographic signs will be examined in detail later in this section. However, not all cartographic symbols are universal. Topographic map signs are universal, using blue lines for streams, black lines for railways, red and white lines for roads, green signs for natural vegetation, black squares or rectangles for buildings and so on. Thematic map signs are not universal, although the major types of thematic cartographic signs - circles, squares, triangles, bars, isolines and choropleths - are universal.

Whether the symbols are useful or not, one cannot eliminate symbol thinking by equating signals with symbols. Further, Royce's belief that the difference between signals and symbols is the difference of one-to-one and one-to-many meanings fails to consider that the difference is one of quality not quantity. One signal may be substituted for another, and a third for the substitute, but each signal bears the meaning of the first one. For symbols, a cumulative reaction occurs because the new symbol participates in the meaning of the old one. Therefore, symbol formation is an ever-creative activity implied in thought processes.

Since cartographic signs are representations of spatial phenomena they are to some degree removed from the actual referent. The link between the sign and the referent involves the concept of distance. For Werner and Kaplan (1963:40-51) the concept of distance involves not only the sign and the referent, but also the encoder (the cartographer) and the receiver (the map user). As indicated in Figure 3, the development of signs (especially symbols) involves change in the four key elements : the encoder (cartographer) matures; the receiver (map user) changes from using parents as models to using peers to using generalised others; referents become increasingly complex, and the signs become increasingly conventional.

The changes from external to inner form by both referents and signs are integral in this development. The sensorimotor scheme relating to the external form of an object is closely linked to its signal-for-action character. Therefore, the cartographic signal for a house may appear as a greatly reduced view of the roof of the house with the shape of the house being the same as it is in reality. The inner form (the meaning the symbol expresses) of the cartographic symbol for a house is characterised by a reduction of egocentrism and idiosyncracy - the symbol for the house becomes an obscure black square.

Distancing between the cartographer or map user and the referent explains the increasing polarisation between subject and object, whereby a stable world of objects and a stable self are developed from a world of fusion and undifferentiation. Consequently, there is a stage in the relation between person and object when the referent is seen as an ego-independent entity, systematically related to other objects and represented in symbolic form to itself and to other objects. The transition from the external form of a referent (the externalised sensorimotor pattern by which the object is grasped by appreciating the look of it) to its inner form (its meaning transformed into an internalised cognitive scheme) involves the development of an understanding of the increased abstraction that occurs when the distance between symbol and referent increases. Therefore, a tree seen in its external form would resemble the real object in shape (as seen from above). In its inner form the tree is understand as a substantive concept and could be drawn as a green dot.

Similarly, there is a progressive distancing between the person and the symbol. Again, this may be explained by reference to the external and internal form of a sign. With respect to the external form of the sign, distancing between the person and the sign is evident in the progression from media of representation, e.g. body movements and images closely linked to personal activities, to a medium which is function specific in regard to representational reference. In terms of the inner form of the sign, the increase in distance is characterised by a decline in egocentrism and idiosyncrasy. Such a progression is one from the expression of meanings which are highly individualised to the expression of meanings which are highly interpersonalised and serve to represent the same content for the communicants (Werner and Kaplan, 1963:46).

Distancing of sign from referent in the external form is characterised by the decrease of tangible likeness, while the inner form of the referent becomes less bound to a concrete external form and develops into an invariant structure seen as an abstract symbol.

The increase in interpersonal distance between cartographer and map user is important in the transformations involved in the development of symbols.

> "The greater the interpersonal distance between individuals in a communication situation, the more autonomous must be the symbolic vehicles in order to be understood, that is, the more communal and the less egocentric, idiosyncratic and contextualised must the vehicles become."
> (Werner and Kaplan, 1963:49)

The analysis of the interrelations between the four key elements in the distancing process cannot be segmented as they occur concomitantly. All four are influential in the development of a system of symbols.

The concept of distance has been incorporated in several approaches which illustrate the nature of cartographic signs. Robinson and Petchenik (1976:61) refer to distancing as the distinction between

> "those marks that are visually completely arbitrary, and those that retain some graphic characteristic that can be visually or conceptually related to the referent."

Consequently, they propose a linear continuum of map signs from "mimetic depiction" through to "arbitrary depiction." Mimetic signs are those symbols which bear resemblance to the referent. e.g. pictorial symbols such as a drawing of several trees from a side elevation to represent a forest. At the other end of the continuum, arbitrary symbols bear little resemblance to their referents, e.g. a cluster of green oval shapes to represent the extent of a mixed forest. Robinson and Petchenik (1976:62-63) extend this continuum to thematic symbols and to typography. In regard to thematic signs, e.g. population grouped by intervals, mimetic symbols consist of circles of proportional sizes whilst the comparable arbitrary symbols consist of variable shapes. For typography, mimetic presentation is evident in variations in size of the one typeface. Arbitrary symbolisation of typography consists of variable type size of different typefaces. Robinson and Petchenik proposed the above continuum to reduce the difficulties in classing symbols as either mimetic or arbitrary.

Muehrcke (1972:37) did the same with cartographic symbols by classifying them as natural, semi-natural and arbitrary. Natural symbols, e.g. a silhouette image of a skier or a fisherman in a boat, resemble an image of the phenomena depicted. Semi-natural symbols, e.g. a sinuous line representing a river or a dotted line representing a road, display intermediate level abstractions whilst generalising the essential characteristics of their referents. Arbitrary symbols display the highest level of abstraction to generalise their referents via line , point and area symbols, e.g. a triangle may represent a park or a dot may represent a railway station.

The ranges detailed by Muehrcke, Robinson and Petchenik,pertain only to cartographic symbols and make no allowance for cartographic signals. For example, the cartographic signal for a clump of trees on an orthophotomap is more realistic (i.e. has more external form) than the pictorial symbols of trees which a child draws on a map. Therefore, the range or continuum should start with cartographic signals rather than natural or mimetic, pictorial symbols, and continue through to abstract arbitrary symbols.

This continuum is illustrated in Figure 17 for the referent house. At the signal level, the house is drawn as a duplicate of the plan view of the house. At the ikonic/mimetic level, the house is represented as a pictorial symbol. However, at the abstract symbolic level, the house is presented as a small black square which bears little visible relationship to the house referent.

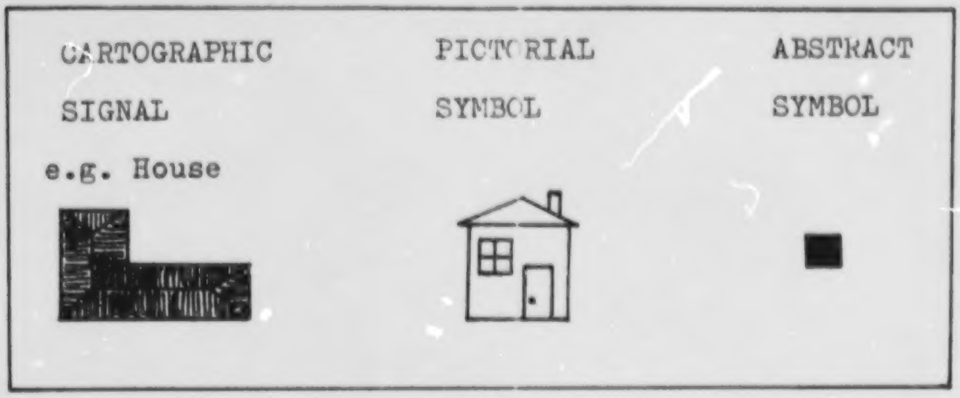


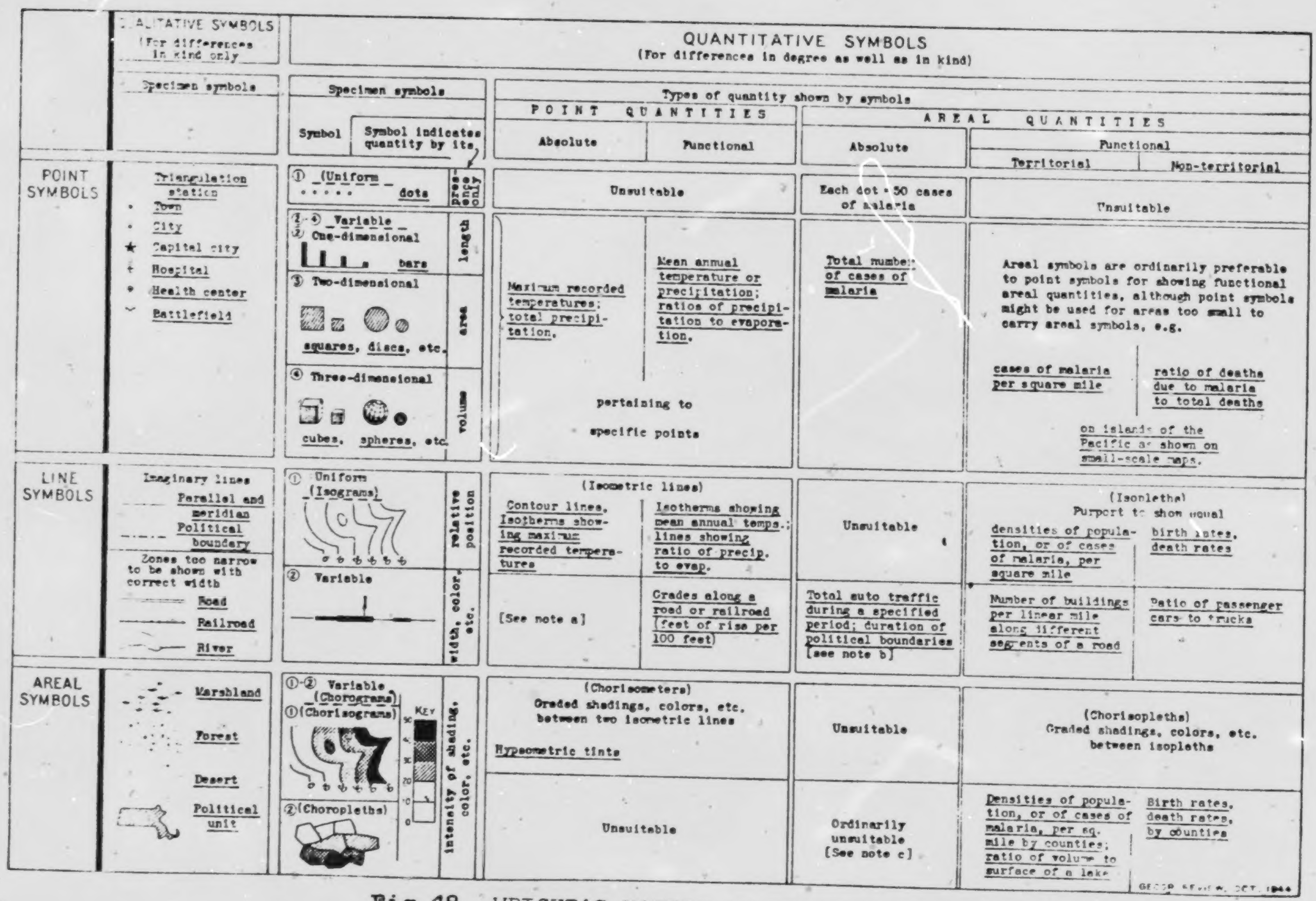
Fig. 17 CONTINUUM OF CARTOGRAPHIC SIGNS USING THE SIGN FOR A HOUSE AS AN EXAMPLE.

The classification of cartographic signs has varied little since Wright presented his matrix in 1955. This matrix is based on the assumption that phenomena studied by geographers can be classified according to dimension : point signs have no dimension, line signs have one dimension, area signs two dimensions and volumetric signs have three dimensions. Figure 18 portrays Wright's matrix. It may be analysed from the aspects of types of sign and the information presented by the signs.

The three types of cartographic signs are line, point, and area signs. Point signs usually represent places or locations. Conventionally the centre of the point indicates the location of the information represented, e.g. a city. Line signs possess conventional widths, but conform in length and direction to the lengths and directions of the information represented, e.g. a river or a road. Area signs are consistent in both shape and size with the shape and size of the information represented, e.g. a forest or a country. Three dimensional signs are usually variations of point signs, e.g. spheres representing the populations of cities, and do not constitute a separate kind of cartographic signs. Since they are perceived as two-dimensional signs (Ekman and Junge, 1961), they serve little purpose on maps.

The information presented by cartographic signs may be organised qualitatively and quantitatively. Qualitative presentation involves the location of the information on a map in a position commensurate with its actual location in the area being represented.

Quantitative presentation of cartographic information involves the presentation of additional information about the phenomena represented, e.g. differences in degree or in quantity. By Wright's definition of quantitative cartographic signs (1944:651), the quantities depicted may be absolute or functional (i.e. averages, ratios or coefficients). Examples of absolute quantitative data include annual precipitation and contour lines. Functional quantitative data may be classified into territorial data (e.g. cases of malaria per square kilometre) and non-territorial data (e.g. ratio of passenger cars to trucks).



	QUALITATIVE SYMBOLS (For differences in kind only	QUANTITATIVE SYMBOLS (For differences in degree as well as in kind)						
	Specimen symbols	Specimen symbols		Types of quantity shown by symbols				
				POINT QUANTITIES		AREAL QUANTITIES		
		Symbol	Symbol indicates quantity by its	Absolute	Functional	Absolute	Functional	
							Territorial	Non-territorial
POINT SYMBOLS	Triangulation station Town City Capital city Hospital Health center Battlefield	① (Uniform) dots	presence only	Unsuitable		Each dot = 50 cases of malaria	Unsuitable	
		①-④ Variable ② One-dimensional bars	length	Maximum recorded temperatures; total precipitation.	Mean annual temperature or precipitation; ratios of precipitation to evaporation.	Total number of cases of malaria	Areal symbols are ordinarily preferable to point symbols for showing functional areal quantities, although point symbols might be used for areas too small to carry areal symbols, e.g.	
		③ Two-dimensional squares, discs, etc.	area				cases of malaria per square mile	ratio of deaths due to malaria to total deaths
		④ Three-dimensional cubes, spheres, etc.	volume	pertaining to specific points			on islands of the Pacific as shown on small-scale maps.	
LINE SYMBOLS	Imaginary lines Parallel and meridian Political boundary	① Uniform (Isograms)	relative position	(Isometric lines) Contour lines, Isotherms showing maximum recorded temperatures	Isotherms showing mean annual temps.; lines showing ratio of precip. to evap.	Unsuitable	(Isopleths) Purport to show equal densities of population, or of cases of malaria, per square mile	birth rates, death rates
	Zones too narrow to be shown with correct width Road Railroad River	② Variable	width, color, etc.	[See note a]	Grades along a road or railroad (feet of rise per 100 feet)	Total auto traffic during a specified period; duration of political boundaries [see note b]	Number of buildings per linear mile along different segments of a road	Ratio of passenger cars to trucks
AREAL SYMBOLS	Marshland Forest Desert Political unit	①-② Variable (Chorograms) ① (Chorisograms) KEY 50 40 30 20 10 0	intensity of shading, color, etc.	(Chorisometers) Graded shadings, colors, etc. between two isometric lines Hypsometric tints		Unsuitable	(Chorisopleths) Graded shadings, colors, etc. between isopleths	
		② (Choropleths)		Unsuitable		Ordinarily unsuitable [See note c]	Densities of population, or of cases of malaria, per sq. mile by counties; ratio of volume to surface of a lake	Birth rates, death rates, by counties

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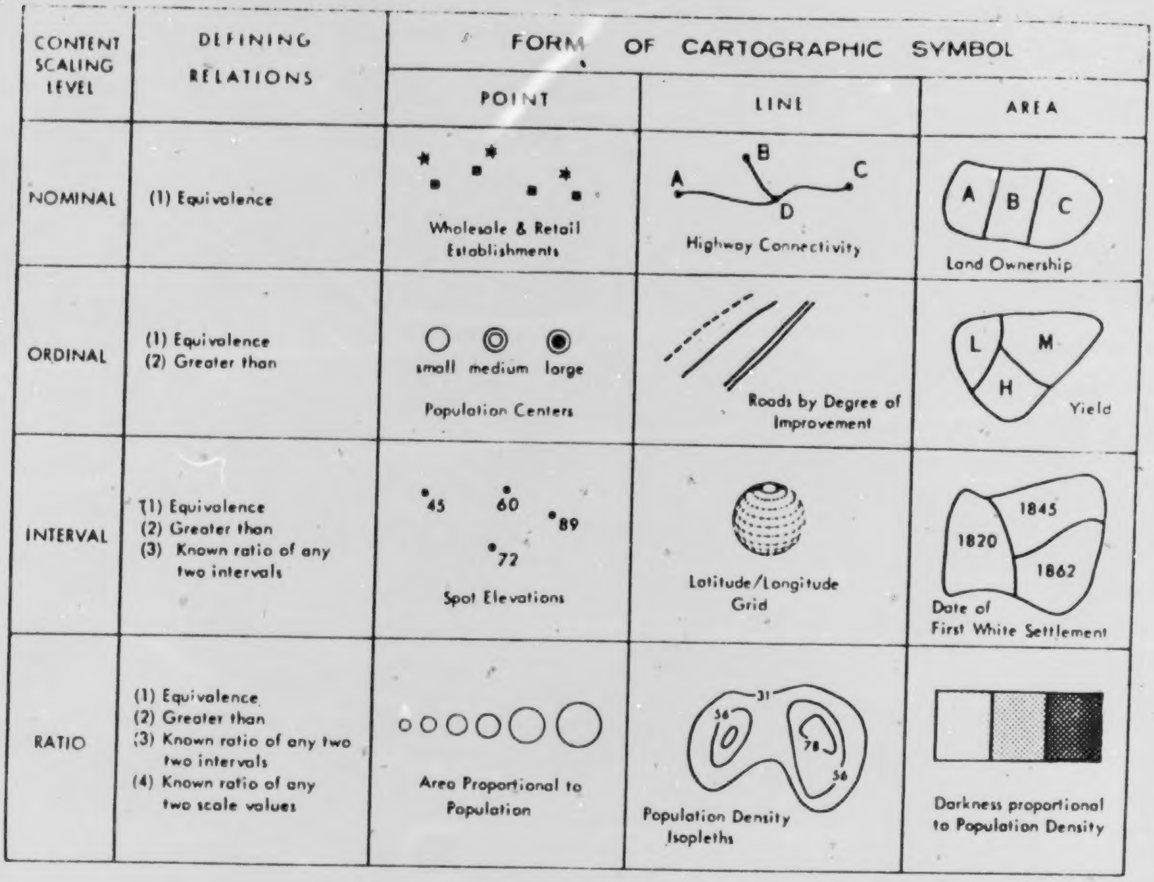
Fig. 18 WRIGHT'S MATRIX OF CARTOGRAPHIC SIGNS

More recently, attempts have been made to systematise Wright's matrix. Robinson and Sale (1969:95-96) explain that the basic methods of differentiating information consist of nominal, ordinal and interval scales. Nominal scaling is classification without concern for rank, e.g. desert and forest (area) and rivers and railways (lines). Ordinal scaling involves both classification and rank, e.g. major cities and minor cities, and high birth rates and low birth rates. Interval scaling subsumes the data for nominal and ordinal scaling and includes some indication of distance between the ranks, e.g. the scale for hypsometric tints. Muehrcke (1972: 14-15) has refined the scaling of cartographic information to four levels by the addition of ratio scale to the three suggested by Robinson and Sale. His matrix of the measurement levels underlying cartographic information graphically illustrates the four levels: nominal, ordinal, interval and ratio. Such a matrix should serve as a general guide to cartographers regarding the range of quantitative signs available for use on maps. When it is added to Wright's guide on qualitative signs, cartographers and map users have a working base regarding the nature of cartographic signs.



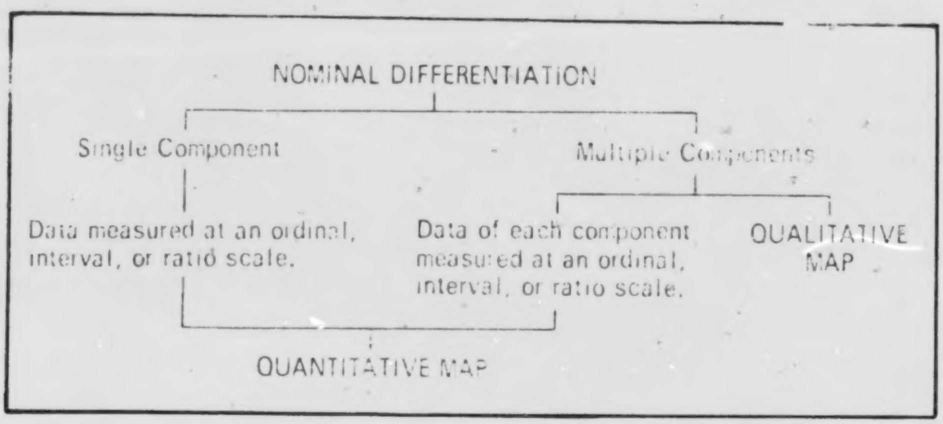
CONTENT SCALING LEVEL	DEFINING RELATIONS	FORM OF CARTOGRAPHIC SYMBOL		
		POINT	LINE	AREA
NOMINAL	(1) Equivalence	Wholesale & Retail Establishments	A B C D Highway Connectivity	A B C Land Ownership
ORDINAL	(1) Equivalence (2) Greater than	small medium large Population Centers	Roads by Degree of Improvement	L M H Yield
INTERVAL	(1) Equivalence (2) Greater than (3) Known ratio of any two intervals	45 60 89 72 Spot Elevations	Latitude/Longitude Grid	1845 1820 1862 Date of First White Settlement
RATIO	(1) Equivalence (2) Greater than (3) Known ratio of any two two intervals (4) Known ratio of any two scale values	Area Proportional to Population	31 56 78 56 Population Density Isopleths	Darkness proportional to Population Density

(after Muehrcke, 1972)

Fig.19 MEASUREMENT LEVELS UNDERLYING CARTOGRAPHIC INFORMATION

Despite the usefulness of these scales for measuring cartographic symbols, Chang (1976:64-67) has detailed three problems which require clarification: (a) the nature of combination of measurement scales; (b) the correspondence between measurement scale and map symbol;and (c) the effect of data classification. Chang suggests that quantitative information on maps usually occurs in combinations of measurement scales, e.g.nominal-nominal,and ordinal and interval. He suggests that

Robinson and Sale (1969) propose random combinations. Chang proposes a conceptual structure for the combination of measurement scales (Figure 20). This structure characterises the nominal scale as single factor and multiple factor each of which may be measured at ordinal, interval or ratio scales to produce a quantitative map.


NOMINAL DIFFERENTIATION
Single Component
Multiple Components
Data measured at an ordinal, interval, or ratio scale.
Data of each component measured at an ordinal, interval, or ratio scale.
QUALITATIVE MAP
QUANTITATIVE MAP

(after Chang,1976)

Fig.20 RELATIONSHIP BETWEEN MEASUREMENT SCALES AND THEMATIC MAPS

Area symbols on monochromatic maps where the variations in the design of area symbols are based on area patterns for all types of scale are examples of the problem between measurement scale and thematic map symbols. Here symbolisation is independent of measurement scale. The link between measurement scale and map symbols is more evident in the selection of point and line symbols, e.g. point symbols can be distinguished by shape or colour at a nominal scale. Different sized point symbols can be developed at ordinal scales and the size of the point symbol can be made proportional to the quantity represented for the ratio scale.

The thematic cartographer uses data classification during the generalisation process. The numerical aspects of interval and ratio scales are lost via data classification. Therefore, ratio and interval scales become the same as the ordinal scale since the known distance between individual values has been lost.

Even so, cartographic symbolisation should depend on the level of measurement scale. Data differentiation enables the study of the relations between data and cartographic symbols from a logical, efficient approach.

Alphanumeric signs - place names, spot heights and feature names - are necessary on maps to provide relevant detail. Imhof (1963) has detailed rules for their position on maps. Honick (1970) concluded that their legibility is enhanced via the use of bold, black sans serif typeface, definite height/weight and height/stroke width ratios, and high contrast when names are overprinted on other signs. The excessive use of alphanumeric signs can clutter a cartographic display and restrict the transmission of the cartographic message.

In its broadest sense, cartographic language includes the standard elements (Isdale, 1978) which are included around the margins of maps. These elements: scale, title, a reference system or grid,direction indicator, legend and so on , are cartographic signs in their own right. They do not serve to represent specific objects or areas as the majority of cartographic signs do. Rather their purpose is one of organisation - scale enables the user to make distance measurements on the map, direction indication via a north point permits the user to orientate the map contents, and a reference system permits the user to locate objects accurately. The standard elements are organising concepts in cartography whereas line, point and area signs are substantive concepts. Both types of concepts can be represented by signs on or around the margins of maps. They are both essential to maps. Therefore, both should be included in the concept of cartographic language.

If the above matrices were all that were necessary to formalise the signs used on maps, then cartographers and map users could become competent in cartographic language with training. It is difficult to proclaim a grammar for cartographic language and a cartographic vocabulary because cartographers use three kinds of signs (line, point and area) to represent four classes of geographical information - point, line, area and volume and because some signs can represent both nominal and interval scales simultaneously.

Good cartographic signs should be universal (Chao, 1968:225-226). Therefore, the optimum state would be for all cartographic signs to be standardised. For this to occur, cartographers would have to adhere to Ratajski's four principles for constructing cartographic signs:

(i) Adjust the graphic expression of a sign to given degrees of classification, e.g. the simplest and most abstract signs will belong to the highest degree of classification, whilst the more pictorial signs belong to a lower degree of classification.

(ii) Adhere to substantial isomorphism (i.e. signs of distinct shape should correspond to comparable groups of information),e.g. line signs for linear referents. The higher the hierarchic degree of groups discriminated, the more decisive the graphic character of the sign ought to be.

iii) Make most efficient use of cartographic signs leading to combinations of signs to accumulate information and to save map space.

iv) Enable the transmission of information concerning the magnitude of a given phenomenon (i.e. develop thematic maps) (Ratajski, 1971:45).

In addition, Vasmut (1966:61-66) elaborates the regularities which are necessary for correct recognition of a sign: (i) simplest signs are most discernible; (ii) discernibility of signs increases if the elements of the same order of visibility remain in their outline; (iii) the basic features of the configuration of a sign ought not to dominate over discriminating informative features; and (iv) a sign ought to contain the optimum number of discriminating informative features.

Similarly, Arnberger (1974:21-22) stresses the formulation of a number of preconditions necessary for the standardisation of cartographic signs. Arnberger's preconditions include:

i) The qualitative differentiation of these signs which is bound to the specific forms of signs, must be exactly and internationally determined, e.g. meteorological signs for clouds are the same throughout the world and each sign has the same international definition.

ii) The unification of quantitative signs requires precise values and gradations of quantity so that each sign presents a uniform representation of quantity of particular phenomena, e.g. wind velocity and earthquake force.

iii) The objects of representation must be simple and internationally comparable in their meaning, e.g. a river or an airport.

iv) The conception of models (signs) for representative objects must be warranted. Hypothetical models which are subject to the changes in one's conception should be excluded from an international cartographic code.

v) Multi-structural signs which represent complicated and changing structures of objects or illustrate causal influences should be avoided because they are usually based or regionally different causal complexes, e.g. signs representing changes in an urban area.

The standardisation of cartographic signs which is vital to the proclamation of a full cartographic language has been successful in some areas, especially in regard to topographic features, and is still developing in thematic mapping. Komkov (1971) and Joly (1971) have elaborated the progress in cartographic standardisation during the nineteenth century when the Greenwich merdian was adopted as the standard and progress was made in the standardisation of writing geographical names. Since then cartographic standardisations which have occurred include: (a) a graticule (a network of lines of a map representing meridians of longitude and parallels of latitude); (b) a grid (a referencing system in which points are defined by their distances from two axes at right angles to one another) (Arnberger, 1974:20); (c) isolines representing altitude (contours), temperature (isotherms) and atmospheric pressure (isobars); (d) the dimensions of water (e.g. rivers, lakes, non-perennial streams); (e) three-dimensional representation of relief by hillshading; (f) symbols for minor landforms (e.g. landslides); (g) genetic pictorial rock signs used on geological maps; (h) settlement outlines; and (i) pictorial symbols for the main forms of agriculture, e.g. wheat and rice. Topographic map forms, therefore, are the main avenues through which cartographic language, as it has been developed, is utilised.

It is in the area of standardising thematic cartographic signs that difficulties occur because individual cartographers attach their own meanings and configurations to signs representing quantitative information. Board (1973:231) identified two broad approaches toward standardising thematic signs: (a) development of associations between concepts and the form of a sign expressed in sign form or colour (This approach is very relevant for interval signs); and (b) the use of abstract forms of signs which are simple and are suitable for continuous scaling. Arnberger (1974:22) identifies maps of world-wide communications (e.g. air routes and transmission of diseases) and those representing qualitative properties of natural laws (e.g. climate, geology and ocean currents) as the two groups suitable for standardisation. He has also concluded that, despite the immense variety of thematic cartographic features, most thematic maps are based graphically on four basic principles: (a) the topographic principle which emphasises exact location and correct delimitation of areal information; (b) the principle of diagrams which offers exact and measurable messages on the value of objects at the expense of exact location; (c) the pictorial - statistical principle which uses individual signs for unit value and offers exact information on the size of objects; and (d) the pictorial principle which uses pictorial symbols to generalise about the phenomena of an area (Arnberger, 1964:30-52). Of these four principles, only the topographic principle is suitable for standardisation since the other three principles lead to diagrammatic maps which are not true maps in terms of their representing the spatial phenomena of an area.

Most attempts at standardising thematic signs have focused on the simplification and logical coding of these signs. Nikishov and Preobrazhensky (1971:128) stress that the unification of thematic cartographic signs should be based on their being visible, compact, comprehensible, reducible (for scale variations),and facilitating standardisation, automation and mechanisation of cartographic processes. Therefore, they propose star signs for power stations and geometric signs for mining activities (along with variations in colour) as samples of their approach to the standardisation of thematic signs. Ratajski (1971:147-158) has proposed the standardisation of thematic signs on the basis of the characteristics of Chinese ideograms (characters). Each cartographic sign should consist of a guiding element (shape and/or colour) and a further extension to specify its semantic sense. The external shape of the sign determines the discernibility of specific signs in a system. Ratajski's system of economic signs emphasises the importance of phenomena and their mental associations with other features. Colour should be used as a definite discriminator.

Rado and Dudar (1971:162) in their study on the standardisation of transport signs see the key principles as : (a) the adoption of those signs generally accepted now; (b) uniformity of typography and drawing technique; (c) uniform interpretation of shape, colour and meaning; (d) reductibility of symbols when generalisation is necessary;and (e) clear definition between the different branches of transportation. Their procedure is to find the lowest common denominator in any class of signs and to build on this. Therefore, for roads,the cartographer commences with a broken line for a track and by adding thicker lines and finally a red colour he represents a major highway.

Lehman (1972:28-32), using the method devised by Kugler for morphological mapping, stresses that progress in thematic cartography can be made by subdividing the content of a complex into elements which may be incorporated into one system, e.g. geomorphological relief analysis. He argues, in an anti-Gestalt way, that by separating the thematic map into such elements, it is possible for the map user to realise the relationship of individual forms and to integrate these individual forms into groups of forms of different orders of magnitude. Providing the scale allows for individual forms, this approach allows for the development of uniform systems of symbols which are prerequisites for standardised thematic maps and which also permit automated cartographic reproduction.

The desirability of using colour to discriminate these signs permeates the above research into standardisation of thematic signs."The only reliable way to describe colour is with reference to some generally accepted standard",e.g. the Munsell colour chart (Board, 1973:233). Standardisation of colour in cartographic signs has been achieved in geological mapping and to a large extent in hypsometric tinting. Pundits for standardisation (e.g. Ratajski, 1971:150) declare that further unification involving colour in thematic signs can be achieved by associating colours with the intensity or importance of phenomena. Colours can not be used freely as conventional signs, but should evoke specific moods and feelings toward phenomena. Therefore, intense warm colours, e.g. red, brown, orange and yellow, designate important phenomena whilst cool, fainter colours, e.g. blue and green, designate less important phenomena. Consequently, the cartographer and the map user can observe the conventional meaning of colours with reference to warmth and coolness and lightness and heaviness. Colour usually reminds the map user of natural colouring, e.g. blue for water, green for forests and yellow-brown from grains such as maize. Since the gradation of colour corresponds with the degree of development and intensification of agriculture, the best solution is to consider both associations of colours in areal signs regarding agriculture (Ratajski, 1971:148).

Theorists such as Joly (1971:119) perceive the need to standardise thematic cartography. Arnberger (1974:

25-26) and Robinson (1973:26) criticise such a desire because it is not possible (in a complete sense) and is not desirable because it would eliminate the creativity of the cartographer and reduce the aesthetic appeal of some maps. From the map user's viewpoint a certain amount of standardisation is important as it provides security for the map user in working with maps. From the views expressed above, topographic signs are virtually standardised and the useful principles for standardising thematic signs relate to the geometric shape of the sign and its colour.

Therefore, it is valid to state that a complete cartographic language does not exist. What exists are sufficient conventions which delimit a graphic language of topographic signs. These are sufficient to claim the existence of a means of communication termed "cartographic language" - a language characterised by line, point and area signs presented in qualitative and quantitative forms, alphanumeric signs and standard elements.

Summary.

This section has shown that cartographic language is the means by which people communicate using maps. Cartographic language may be investigated from a semiotic viewpoint, with emphasis on syntactics, semantics and pragmatics. A continuum of cartographic signs may be established. It extends from cartographic signals (at the most realistic end) through pictorial symbols to abstract symbols. This continuum is based on the degree of distance between signs and their referents. Cartographic signs may be classified broadly to include line, point and area signs presented in qualitative and quantitative forms, alphanumeric signs and standard elements.

2.50 Development of cartographic language.

Individuals must master cartographic language if they are to maximise the information transmitted by maps. This mastery includes the individual's ability to understand and to use cartographic signs. Shimron's research into the way children learn maps concluded that:

(i) learning a map is a gradual process in which local connections of map elements lead to overall integration of map units,

(ii) learning is aided by the individual observing how map units are simultaneously organised,

(iii) learning a map scheme by scheme may cause the individual difficulties in relating one kind of organisation with another, and

(iv) propositional information in stories assisted the retention of cartographic information (Shimron, 1975:24).

The individual cannot appreciate how the elements of a map are interrelated unless he or she can decode the map.

The ability to decode cartographic signs in reading maps and to encode them in drawing maps is the basis of fluency in cartographic language. This fluency may be termed competence in cartographic language for the individual's ability to understand cartographic signs. It may be termed performance for the individual's ability to use cartographic signs in map drawing. Even though cartographic language has been defined generally as a mode of communication, psycholinguistic studies provide a useful basis for differentiating competence and performance.

The distinction between competence and performance can be traced back to de Saussure's concepts of la langue (the structure) and la parole (the residual variation among things) (Hymes, 1971a: 5-6). Chomsky (1968) adapted these concepts to develop the concepts of competence and performance respectively. Competence or understanding has been defined by Chomsky (1965:6) as the understanding of the grammar of the language which provides the base for creative linguistic behaviour. Campbell and Wales (1970) extend the concept of competence to include the ability to make utterances appropriate to the context (i.e. communicative competence). Hymes (1971a:11-12) also varies the nature of linguistic competence by stressing that it is dependent on tacit knowledge and the ability for use. Van der Geest (1975) has synthesised these approaches to competence by defining linguistic competence as the intuitive knowledge of linguistic rules and communicative competence as the ability to make correct choices from sets of rules.

Therefore, communicative competence is seen as a prerequisite for linguistic competence.

Most of the psycholinguistic research agrees that competence in language is a prerequisite for performance in language. Cairns and Cairns (1976:39) define performance as

> ".....the characterisation of the mechanisms by which sentences are actually produced, perceived and understood."

Di Vesta (1974) sees performance as the productions of the speaker. Therefore, to be able to draw a map, an individual must first be able to understand the grammar (rules) of the signs used to compose a map.

The link between competence and performance is not straight forward. As Chomsky stresses:

> "Competence is one factor in determining performance."
> (Chomsky, 1968:117)

It is not enough to possess internalised linguistic knowledge (competence). The map user must be equipped with a variety of cognitive, perceptual and motor skills that interact with one's linguistic competence (Cairns and Cairns, 1976:37).

When the psycholinguistic views are translated in the cartographic context, competence may be understood as: the individual's understanding of the nature of cartographic signs as representations of spatial phenomena; the continuum of cartographic signs (ranging from signals through pictorial symbols to abstract symbols); the range of qualitative and quantitative signs and their presentation as lines, points, areas or alphanumerals; the scaling of the information presented by such signs (nominal, ordinal, interval and ratio); and the conventions which have been adopted to begin to develop a standard cartographic code.

Similarly, cartographic performance is the ability to use cartographic signs to draw maps.

The investigator is not aware of any previous attempts to link the individual's competence and performance in cartographic language. Based on the above theory, the individual's performance, in cartographic language may be influenced by his competence in cartographic language plus characteristics of the individual including intelligence, visual perception, map-reading ability, drawing ability, home environment, previous experiences with maps and attitudes toward maps.

2.51 Competence in cartographic language.

The individual's competence in cartographic language is his ability to understand the meaning of cartographic signs. It is closely linked to the process of seeing defined by Robinson and Petchenik (1976:68) as

> ".........an active process, a transaction between the individual and the environment, in which the viewer creates some kind of order from the essentially unordered array that is the visual stimulus."

The difference between the individual's identification of a cartographic sign and his proven knowledge (i.e. understanding) of the particular sign constitutes the basic difference between seeing the sign and being competent in the sign. Hanson (1958:18-25) divides the process of seeing into two logical elements - "seeing as" and "seeing that." Seeing as is used figuratively to indicate the noting of resemblances by the individual (e.g. seeing the shape of a country in the clouds); for making sense of drawn figures (e.g. seeing an arrangement of lines as a pyramid); and in making seeing mistakes (e.g. mistaking a bird for an aeroplane). Seeing that or "true seeing" incorporates knowledge into the individual's seeing and eliminates the need to reidentify everything that is encountered. Consequently both vision and knowledge are indispensable elements in the seeing process.

The concept of seeing has been refined by Soltis (1966) into three components: simple seeing, successful seeing,and failures in seeing. Simple seeing does not incorporate the knowledge of the observer and beliefs about what is being seen. Its basic ingredients consist of an observer, something to be seen, and the discrimination of that something by the observer.

When knowledge is utilised in seeing, the individual acquires a belief about what he is seeing. If it is true, this belief constitutes successful seeing. If it is false, it constitutes failure in seeing. The criteria for successful seeing are:

(i) As for simple seeing, the minimum requirements of object, observer and visual discrimination are present.

(ii) The observer utilises some knowledge appropriate to what is being seen.

(iii) The observer acquires a true belief about what is seen, based on the knowledge utilised (Soltis, 1966: 75).

Successful seeing may be achieved at a range of levels. At the simplest level it consists of utilising one piece of knowledge, e.g. urban areas consist of many houses. At a more complex level it consists of the object seen as a multiple unit of related characteristics, e.g. an urban area consists of houses, roads and shops. At the most complex level, successful seeing consists of knowledge about an object beyond its identification, e.g. the urban area is seen as a dynamic system involving a range of inputs and a distinguishable range of outputs. Consequently, one may identify a sequence of levels of successful seeing ranging from the simplest to the most complex:

(i) the perception-recipe level (pictorial),

(ii) the label level (pictorial-verbal), and

(iii) the "other knowledge about" level (verbal) (Soltis, 1966:75-91).

The perception-recipe level was initially defined by Ryle (1956:436) as a knowledge of the look of an object and the ability to apply it in another instance. This kind of basic knowing means that the individual has become familiar with an object from a range of viewpoints. Soltis, like Ryle, argues that individuals learn how things look by seeing them (Soltis, 1966:79). For example, the individual does not have to know what an elephant looks like from every angle to know that it is an elephant. However, it does mean that the individual needs to know what an elephant looks like from more than one viewpoint. The individual can make genuine mistakes at the perception-recipe level if the look of the object is distorted so that it is similar to the look of other objects. In using the perception recipe, the individual has the means for recognising the object as a member of a class of object already known to the individual. In addition, some known perception recipes can be intermixed to create new ones without new visual experiences being necessary. These perception recipes are acquired verbally (Soltis, 1966:81).

Usually, successful seeing occurs at a higher level involving knowledge of the name (label) of the object seen and additional knowledge. Therefore, at the label level, the individual can see an elephant, name it as an elephant and is able to repeat the operation for the next elephant observed. The individual may encounter problems at the label level if some of the classes for storing information about visual objects are too broad.

The individual could apply different labels to the same perceived object. Therefore, one object may be labelled a river, a stream or a perennial stream. The individual is not competent in the facile substitution of one label for another until he knows the range of proper labels for an object. Further, the label applied to an object in a specific situation may depend on the individual's current intentions and psychological state. Therefore, a road is simply a land link between areas of settlement to a tourist,but to a cartographer it is a first class, sealed highway.

The "knowledge about" level is the most complex level of successful seeing. Knowledge at this level used in seeing is expectation-producing or embellishment-producing (Soltis, 1966:105). Expectation-producing knowledge is evident in a generalisation or a principle. Once the individual recognises that an object is a member of a class of objects he can then apply deductively the generalisations pertaining to the class. This leads to certain expectations. For example, if the individual recognises the object as a mountain, he immediately expects it to possess steep slopes, high elevation, inverted cone or wedge shape and a rugged appearance (Imperatore, 1970:176). The relevant recognition and/or identification of the object, e.g. a mountain,is basic to seeing at the "knowledge about" level. Useful expectation-producing knowledge remains untapped until such recognition and/or identification is achieved. Embellishment-producing knowledge of an object gives the object a broader meaning and significance. Unlike expectation-producing knowledge, embellishment-producing knowledge tends to be narrow and specific. For example, in successfully seeing a mountain, the individual is aware that the mountain may be snow-capped, possess no vegetation cover or it may be an isolated peak. This aspect of successful seeing enables the individual to interweave endless amounts of knowledge into the seeing process and gradually makes the knowledge more sophisticated.

If an individual fails at seeing then he has not visually discriminated an object. Failure depends upon the degree of knowledge possessed by the individual. It is the incorrect application of that knowledge in a specific situation. A mistake is made when the observer of a particular object possesses the relevant knowledge, but fails to apply it properly. Belief in the existence of what is seen is essential in any failure in seeing. Therefore, a failure in classifying an object is characterised by a false belief of what the individual sees, e.g. a mountain or a hill. When false characteristics are attributed to objects the individual possesses false beliefs about the particular property of the object seen, e.g. all trees are evergreen. Consequently, a mistake differs from an error in failing to see on the following bases:

(i)The basis for the distinction is in terms of the knowledge possessed by the observer.

(ii)The belief, that only mistakes are corrigible and that both mistakes and errors are half-corrigible to the extent that an observer is able to realise that what is seen is not what it was first taken to be, is false.

(iii) Only mistakes are fully corrigible without the necessity for additional knowledge by the observer.

(iv) There should be provision for a potential alteration of viewing conditions when considering the corrigibility factor so that the observers have equal opportunity to view the object.

(v) The force of the distinction rests on the view, that, in the case of a mistake, the observer can correct himself without need for additional knowledge about the object he recognised incorrectly, whilst in the case of error, this is not possible without additional knowledge being required (Soltis, 1966:123).

If an individual acquires and possesses certain knowledge, there is no guarantee that the knowledge will be utilised. If the individual does not possess this knowledge there is no possibility for utilising it. The implications of these facts for teaching or learning are twofold: (i) children should be taught to recognise a particular instance of an object rather than being taught something beyond their capability and (ii) since possessed knowledge is not always utilised, the teacher should train his pupils to maximise possessed knowledge to enhance visual experiences.

When applied to cartographic signs, the process of seeing consists of two components - identification and comprehension. Identification is the simpler of the two terms. In this context it is used to indicate the individual's ability to label objects appropriately by their look and not be required to apply this knowledge to a different instance. Arnheim states that size variations of each object are organised within themselves, and are related in an orderly manner to other similar, simultaneous variations in the field. Consequently, identity need not be extrapolated from a random display of appearances. The permanent character of an object can be determined when and because the setting is pervaded by orderly perceptual gradients to which the object conforms (Arnheim, 1969;42).

Comprehension is more complex than identification. The main difference is that relevant knowledge is used in the seeing process in an applied sense. In a previous study (Gerber, 1977:53-54), the investigator used the term "recognition" to explain the comprehension process. Since the dictionary, and psychological definitions suggest similarity between the terms "identification" and "recognition", the term "comprehension" is adopted in this study. Arnheim concludes that such a process is "the most useful and common interaction between perception and memory" (Arnheim, 1969:90). Price describes this comprehension process as one of recognition which consists of primary and secondary recognition. Primary recognition is the recognition of familiar colours, shapes, patterns and relational Gestalt qualities. Secondary recognition is the recognition by means of signs - the attribution of characteristics not evident in the object the individual is seeing. For example, an individual looks down from a vantage point and observes a river. If he recognises it as a river he has achieved primary recognition (which is identification according to the definition used in this study). If however, he attributes to that river the characteristics of rivers in general - a winding, narrow body of water, a source and a mouth, stream velocity and so on - he has achieved secondary recognition (comprehension).

The process of comprehension is more complicated for graphic displays including maps. The investigator consulted with Evans(1977) on the cognition of signs. Four components of the individual's comprehension of signs were determined. Firstly, cartographic signs may be comprehended in context (on a map). Secondly,they may be comprehended as an isolated sign in a graphic table, e.g. a black square may be coded as a house in an arbitrary legend. Thirdly, a certain knowledge of a sign can be determined by individuals possessing an unrefined knowledge of the substantive concept represented by the sign. This situation will be refined if the individual possesses a thoroughly-rounded understanding of the particular substantive concept so that he is fully aware of the range of the acceptable attributes of that concept. Finally, the individual, possessing a thorough understanding of a concept, is able to make inferences about the concept in its setting (on the map). Therefore, the cartographic sign can transmit extensive meaning to the map user if he is capable of making inferences, e.g. calculation of the direction of a river's flow from the contour lines on a topographic map. Stringer concludes that making inferences from maps is"the final and ultimate ability" (Stringer, 1976:15). Heamon's research into the ability to 'generalise a distribution' and to 'compare two distributions' revealed development of these abilities at about ages ten to twelve years (Heamon, 1973). Therefore, the process of comprehension of cartographic signs consists of four components which may be organised into the following hierarchy ranging from simplest to most complex:

(i) knowledge of the sign in context,
(ii) knowledge of the sign out of context,
(iii) understanding of the concept represented by the sign, and
(iv) the ability to make inferences using the knowledge from the sign.

An important difficulty impinges on the processes of identification and comprehension of cartographic signs. This difficulty is that one is never sure whether all the children in a class see the same object when they, for example, look at a road sign on a map. This is still valid when they label the sign - "road". Each child's operational milieu (background, culture and experiences) influences his perception of particular visual objects, including cartographic symbols. As a guide, the child's comprehension rather than his identification reflects his understanding of cartographic signs.

The above ideas on the nature of competence in cartographic language are useful to educators when they are organised into a developmental sequence. It is worthwhile reiterating that the emergence of formal operational thinking (in the Piagetian sense), which includes the ability to use and understand symbolic representations, is a slow transition in an individual's thinking from less to more developed structures, with later structures building on and incorporating earlier ones. One such sequence for the development of cartographic language may be the utilisation of signals as a preliminary to understanding and using symbols. Cartographic signals are readily available in orthophotomaps. An appropriate preliminary to the use of orthophotomaps is the use of vertical aerial photographs, especially coloured ones. Coloured vertical aerial photographs are a vital introduction to map reading because

> "One of the most difficult yet most important steps in the process of teaching map-reading to elementary school children is the conceptualisation of map symbols that represent landscape features, i.e. learning to make the transition from reality to symbol." (Riffel, 1969:554)

Since the external form of the signals on the vertical aerial photograph will be evident to the individual (if he is capable of successful seeing) he will have a greater opportunity to decode the spatial information than if it was presented in an abstract form. In a previous study (Gerber, 1977:82-128), the investigator concluded that the identification and comprehension of cartographic signals proceded the identification and comprehension of cartographic symbols. Further evidence for the preliminary use of vertical aerial photographs in mapping is obtained from Harris(1959:4) who concludes that children should be taught that a map symbol represents something real on the earth and not a word. Douglass(1967:356) also concludes that the initial years of map study should focus on the development of concepts relating to common features of the landscape to lead the learners to understand what the signs represent.

Research into children's competence in cartographic language has been of two types: (a) studies focused on children's understanding of selected signs and (b) studies which have examined cartographic language indirectly through the investigation of children's understanding of cartographic concepts.

Studies focussing on children's understanding of selected cartographic signs are few in number because of the limited attention this aspect of maps has received. Bartz (1965),in her study of map design for children, sought to find out what 233 children aged ten through fifteen years understood of symbolisation in general, as well as their knowledge of specific signs. Bartz investigated the areas of general comprehension of what a map shows, latitude and longitude, direction, scale, symbols, layer-tint, political area depiction, lettering, insets, generalisation and miscellaneous aspects. The tests in this study were based on maps drawn on a wide variety of scales (1:1,000,000 to 1:42,000,000), drawn from several projections and physical and topographic types. The conclusions and recommendations of this major study include:

(i)Symbols cannot be understood without a legend. The legend should be conspicuous because of the poorly-developed habit of searching for a legend. The only symbols which were fully comprehended were a black dot representing a town or a city, a star representing a capital city, a wavy blue line representing a river and a blue area representing a lake or an ocean. Finally, map symbols are learned later than other simple cartographic symbols. Consequentially children develop the ability to interpret cartographic symbols later.

(ii) All children understand what direction means and are familiar with the cardinal points: north, south, east and west, but are not competent with intermediate directions, e.g. south-east. Even though the convention is to place north to the top of the map, children become confused when the north point is missing. Therefore, direction indication on a map must be frequent and clear.

(iii) Children are not immediately aware of the concept of scale. Even when a graphic scale is presented on a map children often do not refer to it. By age twelve or thirteen years the children refer to the scale frequently for simple distance problems. Most children have not developed any systematic procedure for using a graphic scale. Scale expressed as a representative fraction is not understood at all.

(iv) Layer-tinting (the use of colours to show elevation classes) carries very little information. it serves mainly to emphasise other means of depicting relief (e.g. hillshading). Children preferred to associate a colour change with a qualitative change, e.g. mountain to plain (except for water where shades of blue were preferred). Because children often do not refer to **the** legend to explain the meaning of colours, the legend of tints should be proximate to the map area. Also because children do not readily visualise "1000 to 2000 metres above sea level", this colour range should be defined as mountains.

(v) Children experienced considerable difficulty identifying countries by lines drawn around the country. They were competent in identifying countries on the basis of colour change. Further, their terminology of political units was lacking so that understanding the concept of "country" or "continent" caused problems.

(vi) In regard to lettering:

> "The child is more conscious of the names on the map than he is of any other element. His understanding of much of the other symbolisation depends upon how readily the names are seen and understood." (Bartz, 1965:44)

The factors which affected the child's reading of names on a map included: familiarity with the name, alignment and spacing of letters and words, type size, style and weight, and the map background. Children usually fail to tell one type face from another. Abbreviations of names were understood poorly by children, e.g. "C." for cape and Is. for island.

In a previous study (Gerber, 1977), the investigator examined children's competence in selected cartographic signs presented as signals and/or symbols on vertical aerial photographs, orthophotomaps and topographic maps, at a scale of approximately 1:20,000. The main conclusions of this study indicated that:

(i) Children aged ten through fifteen years displayed variable degrees of competence with different cartographic signs. Also differences occurred with selected signs which are presented as signals or symbols. Qualitative point signs (e.g. house) were comprehended by children from age ten years when the signs were presented as separate signs, but when a range of point signs for buildings were used pupils aged thirteen years displayed incompetence. Qualitative line signs (e.g. roads) were not fully comprehended by children up to age fourteen years when the signs were presented as symbols. Signs for trees were comprehended as point signs by children from age ten years whether they were presented as signals or symbols. When trees were represented by abstract symbols they were not fully comprehended by children up age fourteen years. Children up to fifteen years of age lacked competence in comprehending quantitative line symbols, e.g. contour lines.

(ii) The distance between sign and referent was a major influence in pupils' understanding of cartographic signs.

(iii) There was no significant difference between the sexes in pupil competence in cartographic language.

(iv) Colour in cartographic signs facilitated the identification and comprehension of these signs for pupils aged ten years through fifteen years.

Studies which have examined cartographic language indirectly through the investigation of children's understanding of cartographic concepts are more numerous and of less significance to this study. They range from comprehensive test batteries to studies of specific concepts. The investigation by Brown _et al_. (1960)

into the optimum age at which different types of map questions may best be set to pupils in the teaching of geography illustrates the former type of study. Included in the conclusions of this study were the following:

(i) The best ages to work on scale are from twelve to fourteen years.

(ii) By age eight years children can work with contour lines to appreciate relative height.

(iii) By age eight years children can use conventional signs, but direction proved to be a difficult concept.

(iv) Age eleven years is the age of accuracy and simple map reading tasks are accomplished by age twelve years.

(v) A range of map scales was used (e.g. 1:2500, 1:25,000, 1:63,360 and smaller scaled atlas maps), but pupils displayed a preference for and a competence with larger scale maps and maps from a pictorial atlas. By age fourteen years the pupils displayed greater ability with a conventional small-scaled atlas and its amount of generalisation.

These conclusions were confirmed by Blair (1964) who also indicated that pupils displayed increased understanding up to age fourteen years. Charlton (1975), in her study of pupils' (aged eight to thirteen years) understanding of map symbols, scale, direction and location, concluded that comprehension of these concepts improves with age and that pupils' understanding emerged at an earlier age than expected. She concluded that definite stages of development can be observed for scale and location, but not so for symbolisation and direction, where more depends on teaching. The expressions of earlier pupil ability with maps is reinforced by Pemberton (1970) and by Blaut and Stea (1971). However, these researchers do not state explicitly that understanding of map signs develops at an earlier age. Carswell's study of children's abilities in topographic map-reading where he measured the relation between six map skills (symbols, direction, scale, elevation, grid and interpretation) and intelligence, sex, spatial ability, grade, socio-economic level, age and teachers' knowledge of geography, revealed that symbols and directions are the least difficult skills. These were mastered by middle Primary years. Scale, grid and elevation were of similar difficulty, but were mastered by the end of the primary years. Interpretation is the most difficult skill (Carswell, 1970). Carswell's conclusions regarding symbols are contrary to those of Bartz and this investigation. Perhaps greater consideration should have been given to the abstract symbols on maps and more emphasis on the comprehension process in cartographic symbolisation.

Studies of specific spatial concepts have limited value in regard to cartographic signs. Towler and Nelson's study on the development of the concept of scale indirectly influences the children's ideas on the size of cartographic signs (Towler and Nelson, 1968). Their conclusion that children do not develop a concept of scale before ages ten or eleven years reflects on the children's ability to comprehend different types of cartographic signs, especially if they attempt to relate the scale of the map to the size of the signs. Cobb and Stoltman (1973) in their study of perspective ability and map conceptualisation in primary school children conclude that children experiencing difficulty co-ordinating perspectives experienced a similar difficulty conceptualising the spatial relations of signs on a map. They proposed a developmental sequence in the conceptualisation of spatial relations on a map, influenced by prior experience and training. The sequence states that by age twelve years children have mastered the ability to conceptualise relative positions of objects from different viewpoints. Miller's study of perspective ability also revealed that pupils around twelve years of age have well-developed perspective co-ordination ability (Miller, 1967). Studies of geographical orientation by Howard and Templeton (1966:256-267) indicate the definite need by the map user to appreciate the convention of north pointing to the top of the map and to comprehend the sign on the map indicating direction (the north point). If these skills are not understood the map user cannot orientate the map. Shemyakin (1962:242-243), reporting the research into children's understanding of cardinal points by Kabanova-Meller, stressed the need to establish a "tie-in" of the cardinal points with the main directions of the human body before these directions are imposed on a map.

Another indirect means of analysing children's understanding of maps is via an analysis of their spatial reasoning as applied to maps. One such example of this analysis is the task devised by Salomon and Feldman (1969) to assess skills required for map drawing. This task was based on a conceptual analysis of a map which attempted to specify the skills needed for map understanding (Salomon, 1968). All items in the task were devised concerning a map of an imaginary island. They were devised to elicit responses corresponding to Piaget's four reasoning levels in his theory of cognitive development which Salomon and Feldman termed:(a) tautological/imaginative reasoning, (b) perceptual/ associative reasoning, (c) concrete reasoning,and (d) formal reasoning. By assigning values to each of these four levels in ascending order of development, Salomon and Feldman were able to establish a map-reasoning level which was the mean of the responses to the map tasks (Feldman and Markwalder, 1971:349).

The above research findings suggest that the development of competence in cartographic language via the processes of identification and comprehension is unlikely to happen suddenly. Probably, it develops throughout the period of concrete thinking and by the time individuals have begun to think abstractly they will be able to comprehend the abstract cartographic symbols. Map users cannot decode the message encoded on a map unless they are competent in cartographic language.

2.52 Performance in cartographic language.

It is one thing to understand something, but it is quite a different matter for the child to display this understanding through performance. The individual's performance in cartographic language is his ability to use cartographic signs in map making. Gibson (1969:148-149) stressed the lag between the ability to differentiate visual patterns and the ability to produce them from memory. Maccoby and Bee (1965) suggest that drawing a figure requires that its attributes be differentiated and the more attributes of a figure the individual differentiates, the more accurate will be his drawing. Gollin (1960) concluded that distinctive figural properties (e.g. star shapes) influence the accuracy of children's drawings. Piaget and Inhelder (1956: 73-75) stressed the lag in development of representation of shapes of objects compared with their perception. Their discussion of children's drawings is similar to that of Gibson in that the differentiation of the shapes of features shapes memorial representation. This adds weight to the argument that the abstraction of distinguishing features precedes the formation of an appropriate memory image. Gibson further states that children develop both discrimination and representation of features prior to performance. Therefore, perceptual learning (the discovery of distinguishing features and the extraction of invariant patterns and relations - is a requisite for all the three processes and these three processes form a type of cognitive hierarchy (Gibson, 1969:152).

Welford (1971:287-288) associates performance with the acquisition of a skill. He developed a seven-step sequence commencing with the perception and conception of the knowledge required for the skill and involving the retention of this knowledge in the individual's memory. Performance is the culmination of this sequence for it is the means by which the recalled material is used to produce an overt, communicable response, e.g. drawing a map. Welford stresses that the performance is the only observed stage in the sequence. Failure in performance is due to breakdowns occurring at any of the previous perception, conception and memory stages.

Performance via the drawing of maps is seen by Polanyi (1959:24) as a means of reorganising one's knowledge from ever new points of view. Such reorganisation is a tacit performance similar to the way one gains intellectual control over our environment at the pre-verbal level and to the process of creative reorganisation by which new discoveries are made.

The actual performance in drawing a map has been detailed by Beck and Wood (1976). They elaborate the cognitive operations involved in map drawing - rotation, scaling, generalisation, symbolisation, verbalisation, representation and externalisation. Rotation involves the transformation of information perceived in the environment to an orthogonal or aerial view. This difficulty has been stressed by Vanselow (1974) to be of major importance because individuals spend most of their time viewing objects from a horizontal perspective. Therefore, when young children draw features on maps, these are drawn pictorially and they are often drawn "lying down" on the map as they are observed if one walked down a street. Scaling is essential to preserve the proportional arrangement of objects represented on the map. Scaling variations in cognitive maps usually result from the individual's failure to synchronise his environment so that errors occur in the distances between key landmarks. Scaling is closely linked to generalisation since the scaling down of an area to the size of a map sheet will determine the amount of detail that may be retained. Even though detail will be lost during generalisation, the dominant attributes of the phenomena must be retained, e.g. the sinuous nature of a major river. Symbolisation and verbalisation are both parts of the signification process. Symbolisation is the process by which the cartographer selects line, point and area signs to represent the selected, generalised spatial phenomena. There is no evidence that individuals possess a mental legend of cartographic signs. Beck and Wood believe that some form of symbolisation takes place during the experience of the referent. They do not know whether this symbolised experience is stored in the mind as a picture, sign, word or image. However, they feel that when a request for a map has been made, it calls forth a narrow symbol set and the sign is actually the result of of the interaction between the act of drawing, the narrow symbol set and the referent (Beck and Wood, 1976:227). Verbalisation, the process by which places are labelled on a map, involves the pairing of place sign and place name. Again it is not known whether sign-label pairing is stored as such or whether it occurs only when the map is drawn. The operation of representation embraces the act of visualisation whereby the cartographer "holds in his head a picture of what it is he is attempting to draw, discuss or otherwise manipulate" (Beck and Wood, 1976:228). This process is a conscious action and acts as the stage for overt behaviour (i.e. map drawing). Externalisation is the final overt operation whereby a map is produced. It involves using the above operations in a complex interconnected manner as a feedback system which operates over very short time periods.

These cognitive operations depend on a series of prior operations which are perceptual by nature, e.g. sensations, classification, orientation and synchronisation. Although they have been separated for definitive purposes, the distinction between cognitive and perceptual operations is an arbitrary and a confusing one, since perception and cognition are interrelated (Blakemore , 1973; Deregowski, 1973; Maturana, 1970).

The product of this set of operations may be of two types : a free-recall sketch map or a compromise map consisting of a freely-drawn base and given information on a series of overlays.

Most research has been carried out using free-recall sketch maps. The free-recall sketch map was devised by Lynch (1960) and illustrated in studies by Beck, Paris and Wood (1975), Orleans and Schmidt (1972) and Regnier (1974). On this map the cartographer creates a base map on which he overlays additional material. The resultant map tends to accumulate and exaggerate error, e.g. if the scale is erroneous the map will appear to bear little resemblance to the area represented. However, if the errors are exaggerated they provide information about the deficiencies of the cartographer. These deficiencies may relate to the level of thinking of the individual or to genuine mistakes in constructing the map.

One of the most definitive researchers into free-recall sketch maps has been Feldman, who with his associates Snyder and La Rossa, has quantified these maps. Snyder et al. accept the Piagetian approach to map drawing which is defined as follows:

> ".........The construction of a diagram or plan entails (i) the selection of a particular point of

> view, together with certain pictorial conventions intended to express it...... (2) a system of co-ordinates - - whose function should be self-evident - - along with the implied concepts of straight lines, parallels and angles. (3) reduction to a specific scale which entails the concepts of similarity and proportion. Hence the construction of a diagrammatic layout incorporates in a single entity all the concepts examined ..... and at the same time shows how they are related to one another." (Piaget and Inhelder, 1956:426)

Therefore, Snyder et al. conclude that map drawing provides one vehicle for studying the development of three spatial concept systems : perspective, reference systems and proportion , as well as the symbolisation by which they are expressed (Snyder, Feldman and La Rossa, 1975:2). In addition they accept the Piagetian approach that the development of map drawing is the co-ordination of two sets of correspondences between the map and the area it represents:

(i) logical-mathematical correspondences concerning the way in which objects or classes of objects which share logical properties (e.g. roads) and numerical collections (e.g. four roads) are represented on the map, and

(ii) spatial correspondence concerning the relationship of represented objects to each other within the overall spatial framework, e.g. how the arrangement, sizes and distances are maintained on the map (Snyder, Feldman and La Rossa, 1975:3).

Consequently, Feldman (1971) devised a six-level sequence of map-drawing categories which was amended slightly to become a six-level sequence of spatial reasoning development as revealed in map drawing (Appendix 1). Snyder et al.(1975) refined their approach to map drawing because they were aware that different features tended to be represented on a child's map at different levels of sophistication, e.g. railways and other flat surfaces are easier to represent from above than buildings. They identified the four broad spatial concepts : arrangement (topological concepts in the lower levels and Euclidean concepts in the advanced levels), proportion (stress on Euclidean concepts, e.g. similarity), perspective (stress of projective aspects), and abstraction/symbolisation (stress on pictorial conventions) , and five feature clusters: buildings, hill, bridge, island, other elevated land (major features); major flat features (lake, river, roads); incidental features (trees, fences, flagpole) and the map as a whole. From this, Snyder et al. were able to devise six-level sequences from which to analyse the individual's map-drawing ability according to arrangement, proportion, perspective and abstract/symbolisation (Appendix 2).

Further research into free-recall sketch maps has been conducted by Shemyakin and Lowe. Shemyakin (1962) concluded that children, when asked to draw a map of a locality known to them, used either a "route" method (i.e. tracing a known route through the represented area) or a "survey" method (i.e. the general configuration of objects in the selected area). Shemyakin found that children aged from six to eleven years used the route method whilst the survey method developed from age twelve years onwards. These map representation categories were synthesised by Wilson (1979) (Appendix 3). Lowe, in the mid 1960's, investigated the ability of British children aged seven to eleven years to draw a map of their route from home to school. The maps were scored on a four-point scale for each of the following categories : position (the relative distance between features), scale and plan (the drawing of features as seen from above). He concluded that for seven year old children position was best understood, followed by scale then plan. The children gradually improved in each aspect as they grew older (in agreement with Piaget). Spatially gifted children were atypical in that they displayed a better understanding of plan at age seven years than for either scale or position.

Research on the alternative compromise map approach to the free-recall sketch map has been limited. Wood and Beck have devised an approach whereby the individual can create his own base, but the amount of information given is controlled by providing overlays of information (Wood, 1973; Wood and Beck, 1971 and 1978). Using their "mapping language" ENVIRONMENTAL A, Wood and Beck make children build their own maps on several surfaces by:(i) creating their own base map in the form of a point-line skeleton, (ii) overlaying areas on tracing paper, and (iii) overlaying symbol attributes for relevant places. Therefore, more information was portrayed than could normally be placed onto a single surface. The process employed here is similar to Sternberg's description of the "smoothing of objects into icons"(1968).

A number of interesting developments are evident in children's map drawing as they develop the ability to draw maps of small and large areas. These developments include the representation of direction, the range of signs to represent phenomena, the understanding of scale and the ability to use a plan view.

Howard and Templeton (1966;236) conclude that there are consistent individual differences in the mode of representing geographical direction. These differences may be classified into stereotypes, e.g. Claparede's realistic type (who aligns the directions of streets and rivers in the map with their counterparts in reality), egocentric type (who orients the map in a constant relation to his body) and his conventional type (who always places the north of the map furthest from himself and the east to the right (Claparede, 1903, 1924 and 1943). The ability to represent direction on a map involves the ability to orient oneself in relation to a map. A child may orient the drawing as a whole and still not use the same spatial reference system for the whole drawing. For example, Piaget and Inhelder (1956) indicated how children used key lines for gravitational reference so that the features on one side of the street were drawn at right angles to the road and as the child walked back down the opposite side of the road, the features were inclined at right angles to that side of the road. Almy (1967), in a Piagetian replication study,indicated similar findings in regard to vertical and horizontal for pre-school and early school children. Hanfman (1933) found that when children were asked to draw a second chimney on a roof, they usually drew it at right angles to the slope of the roof. These views reinforce Vanselow's (1973) contention that these children are dominated by a horizontal viewpoint in their lives. As the children mature so does their ability to include accurate

Euclidean aspects, e.g. angles of roads, buildings and fences, in their drawings.

The drawing of maps involves children appreciating the spatial relationships of the following basic concepts - proximity('nearbyness' of elements); separation (clearer differentiation of objects); order (logical organisation of elements); enclosure ('insideness' of elements), continuity (a continuous spatial field created by the elements) and Gestalt (wholeness). As indicated previously, to envisage the landscape as a whole, the child must organise the objects represented so that they have a logical correspondence as well as a spatial correspondence. The development of graphics such as maps is "a process quite spontaneous in its origins, since it is the product of everything the child has mastered in drawing". It "illustrates extremely clearly its gradual formation of the whole body of concepts, originally topological, eventually projective and Euclidean" (Piaget and Inhelder, 1956:446).

The means by which children present signs on maps they have drawn relates to their abilities to encode signs of varying abstraction and to perceive objects as seen from above. The previous discussion regarding the distancing between sign and referent indicates the relationship between sign and referent, but does not explain how the transformation occurs. According to Haber,an ikonic representation (i.e. a cartographic sign) is

> "........the first central stage of information extraction or the processing of visual stimulation ......(and)......the ikon contains those features that have been extracted by feature detection processes that occur between the retina and the cortex." (Haber, 1971: 36-37)

The information extracted from the ikon is influenced by the milieu operating on the individual (e.g. previous experience with maps) and his familiarity with the cartographic language. Therefore, for some children, the signs they present on their map drawing will look like oversimplified, pictorial, side-elevational views of objects, e.g. trees, buildings and goal posts. These children, through the ikonic resemblance of their signs, reveal the immaturity and concrete basis of their thinking. At the upper end of the scale, children will be able to represent a group of trees with one or two arbitrary symbols which bear little resemblance to the trees represented. Such children indicate competence in cartographic language.

The need to maintain an accurate representation of the area mapped necessitates the map drawer presenting the relevant spatial arrangement proportionally reduced to a scale suitable to the size of the page on which it is drawn. Young children tend to highlight objects familiar to themselves thereby disturbing the arrangement of the objects. The proportion of the arrangement of objects is disturbed by the unrealistic size of some signs. As the map drawers approach Piaget's Euclidean stage of spatial understanding the arrangement of objects becomes proportional to that of the area represented. The importance of proportion in map-drawing is highlighted in the scoring schedule used by Feldman _et al._ to score free-recall maps (Snyder, Feldman and La Rossa, 1975: 21-26).

As such, children's performance in cartographic language is inherent in their ability to draw maps, an ability which does not appear to occur spontaneously, but which develops as the children mature and develop cognitively. Children cannot draw maps successfully unless they possess a competence in cartographic language. However, competence alone does not explain their performance in drawing maps. Wilson (1979) indicates the influence of factors such as nonverbal intelligence, age, reading ability, map-reading ability and verbal intelligence in map performance. No one is sure of the relative importance of each of these factors to map performance although previous research suggests that influential links do exist.

Summary. Therefore, children's development of cartographic language may be investigated through their development of competence and performance in cartographic language. Identification and comprehension were established as key concepts in the children's development of competence in cartographic language. Competence plus a range of individual attributes were found to be important influences on the individuals' development of performance in cartographic language.

3.10 Brief restatement of the aims of the study.

The principal purposes of this study focus on children's development of competence in cartographic language and their performance in cartographic language as expressed in free-recall maps. The children's competence and performance in cartographic language were allied to their map-reasoning level. This study considered children at the concrete level of map-reasoning.

This study has been developed on the assumption that maps are vehicles for transmitting cartographic information. The transmission of cartographic information infers a communication system. Related literature and research over the last fifteen years indicate that this communication is between the cartographer who encodes the cartographic information and the map user who decodes this information at his level of thinking. The literature indicated that a great deal of research had been carried out on the nature of maps and the cartographer's characteristics in presenting maps as graphic displays of information. However, much less research has been completed into the map users' abilities to receive cartographic messages and to produce cartographic messages of their own.

The research suggests that the map user has been neglected as a research target in the past because each map user is an individual who brings different experiences and intelligences (e.g. verbal and non-verbal) to the map-use situation. Therefore, a prime objective of this study is to identify a range of map user variables and to relate them to the map users' competence and performance in cartographic language, as well as to their map-reasoning level.

Children's competence in cartographic language is based on their ability to identify and comprehend cartographic signs. Their identification of a cartographic sign (signal or symbol) precedes its comprehension. Similarly, children's performance in language is influenced by their competence in the language and a range of individual map user characteristics which the children bring to the use of maps.

The methodology of this study has been developed from the following premises:

(a) There is such a thing as cartographic language which, may be defined from the semiotic view in relation to syntactics (the rules for the construction of signs), semantics (the meanings of the signs and the relationship between signs and the concepts they represent), and pragmatics (the relation of cartographic signs to their users).

(b) Individuals develop intellectually as they grow from childhood to adulthood. This cognitive development may be explained by theories such as Piaget's theory of stages in intellectual growth (1954).

(c) The methods of investigation should minimise subjective judgment in the phases of data gathering and classification. Quantitative measures of children's competence and performance in cartographic language and their map-reasoning level should be used, wherever possible, to maintain consistency and regularity in data processing.

The structure of this study is presented graphically in Figure 20.

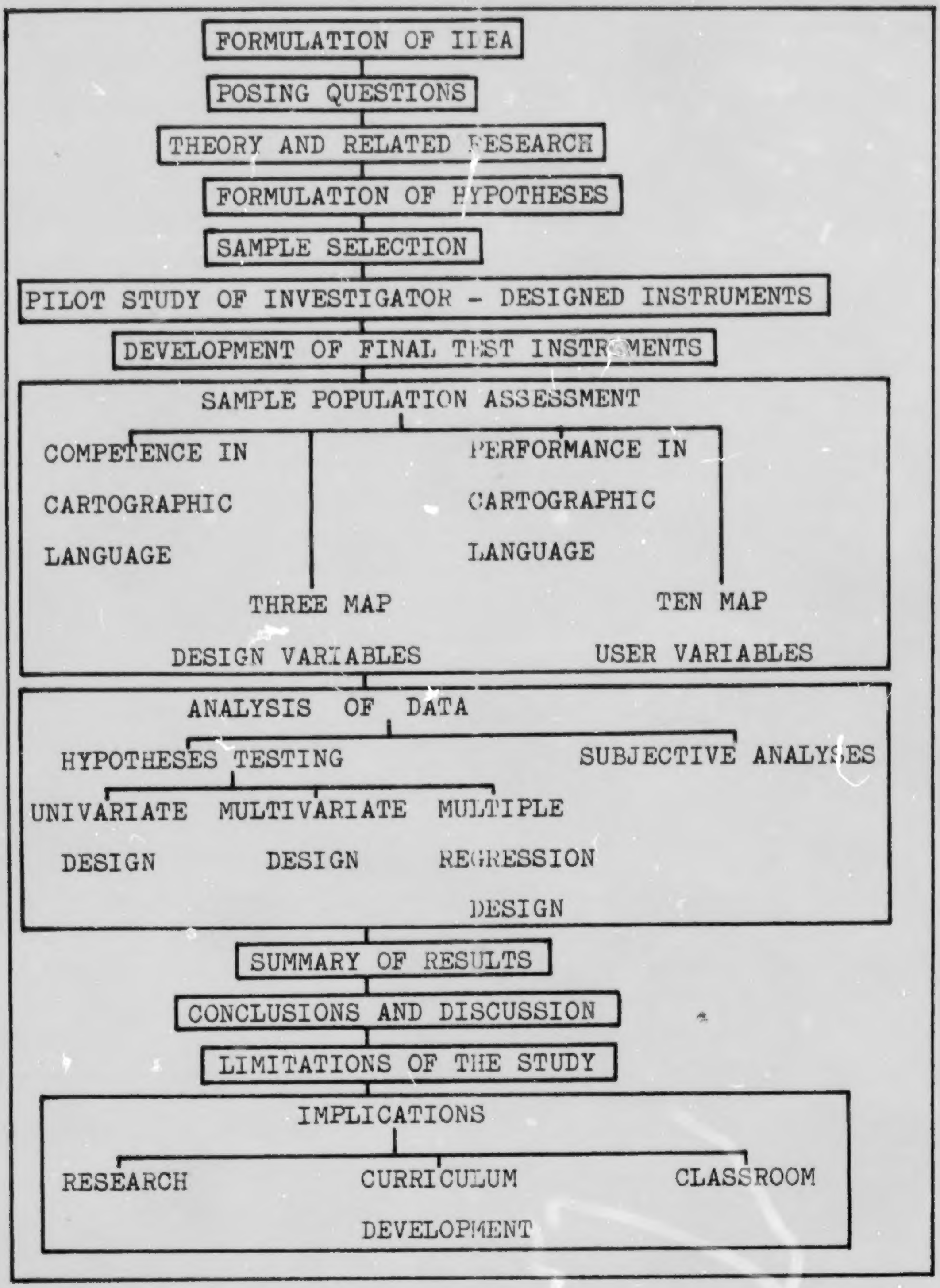

FORMULATION OF IDEA
POSING QUESTIONS
THEORY AND RELATED RESEARCH
FORMULATION OF HYPOTHESES
SAMPLE SELECTION
PILOT STUDY OF INVESTIGATOR - DESIGNED INSTRUMENTS
DEVELOPMENT OF FINAL TEST INSTRUMENTS
SAMPLE POPULATION ASSESSMENT
COMPETENCE IN CARTOGRAPHIC LANGUAGE
PERFORMANCE IN CARTOGRAPHIC LANGUAGE
THREE MAP DESIGN VARIABLES
TEN MAP USER VARIABLES
ANALYSIS OF DATA
HYPOTHESES TESTING
SUBJECTIVE ANALYSES
UNIVARIATE DESIGN
MULTIVARIATE DESIGN
MULTIPLE REGRESSION DESIGN
SUMMARY OF RESULTS
CONCLUSIONS AND DISCUSSION
LIMITATIONS OF THE STUDY
IMPLICATIONS
RESEARCH
CURRICULUM DEVELOPMENT
CLASSROOM

Fig. 20 GRAPHIC PRESENTATION OF THE STRUCTURE OF THE STUDY

3.20 Population and sample selection.

Children from three metropolitan Queensland schools were involved in the study. Some 642 children from Years four through nine were involved. The three schools consisted of two government primary schools and one non-government secondary school. These schools are situated in the western suburbs of Brisbane (the metropolis of Queensland). All of the schools are located in the middle or outer suburbs of Brisbane. School number one is situated in the outer western suburbs adjacent to an industrial area. Most of the homes were built twenty to thirty years ago. This is a working class area in which the residents take some pride in their environment. School number two is located in an affluent western suburb. Most of the homes were built less than fifteen years ago. They are lavishly landscaped. A high proportion of the population is engaged in professional occupations, especially in education. Children at this school have outstanding library facilities. School number three is a denominational girls' primary and secondary school. Its clientele is drawn from throughout the middle and outer western suburbs. It is located in the middle, established western suburbs. Most of the pupils' parents have professional occupations. Therefore, it is assumed that the children in the study group are typical urban dwellers in terms of their location and socio-economic background.

The children in the study group were tested in mid-1978. Fifteen test instruments were administered over a five week period to the study group. 38 children were absent for more than one test. They were omitted the study group on the grounds of incomplete data. Therefore, the actual study group consisted of 604 children. This number was composed of 282 children from school number one, 153 from school number two, and 169 children from school number three. Table 3 indicates their subdivision by Year level. Children in Queensland schools in Year four are aged 8+ years whilst those in Year nine are aged 13+ years.

Table 3 STUDY GROUP POPULATION DEFINED BY SCHOOL AND YEAR LEVEL (Numbers of Children)

SCHOOL	YEAR LEVEL					
	4	5	6	7	8	9
No. 1	85	76	65	56		
No. 2	45	36	36	36		
No. 3					76	93
TOTAL:	604 children					

This study is concerned with children's development of competence and performance in cartographic language. The Salomon-Feldman map-reading test (Salomon and Feldman, 1969) provided the base for selecting the actual study sample. This test scaled the children at one of the four Piagetian - based map reasoning levels. Children at the concrete map-reasoning level scored a mean of 3 on a 4-point scale. The related research indicated that children gradually develop from one reasoning level to the next. Therefore, the range of the concrete level of map-reasoning is from 2.5 to 3.5 on the above 4-point scale. On this basis, four blocks of map-reasoning scores were established using the

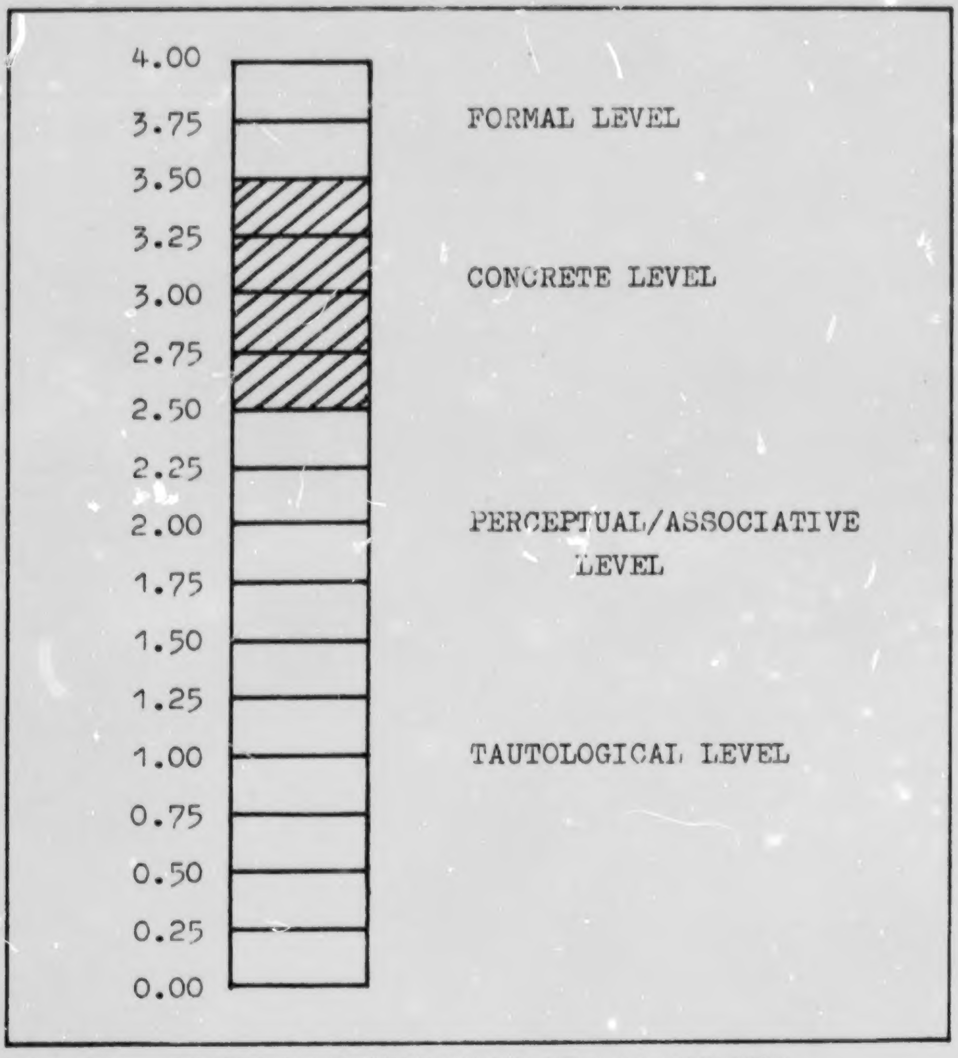

4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
FORMAL LEVEL
CONCRETE LEVEL
PERCEPTUAL/ASSOCIATIVE LEVEL
TAUTOLOGICAL LEVEL

Fig.22 GRAPHIC PRESENTATION OF THE SALOMON - FELDMAN MAP-REASONING SCALE

intervals 2.5 - 2.75; 2.76 - 3.00; 3.01 - 3.25 and 3.26 - 3.50. (see Figure 22). Most children in the study group were classified at the concrete level of map-reasoning. Table 4 indicates that 27 children received map-reasoning scores below 2.5 and Table 5 indicates that 31 children received map-reasoning scores above 3.5. Therefore, 546 children received map-reasoning scores which were classified at the concrete level.

Table 4 DISTRIBUTION OF CHILDREN WITH A MAP-REASONING LEVEL BELOW 2.5 (Numbers of Children)

SCHOOL	YEAR LEVEL					
	4	5	6	7	8	9
No. 1	11	5	5	0		
No. 2	1	2	0	0		
No. 3					3	0
TOTAL:	27 children					

Table 5 DISTRIBUTION OF CHILDREN WITH MAP-REASONING LEVEL ABOVE 3.5 (Number of Children)

SCHOOL	YEAR LEVEL					
	4	5	6	7	8	9
No. 1	0	0	0	1		
No. 2	0	0	0	0		
No. 3					9	21
TOTAL:	31 children					

An even distribution of the study population was achieved when the 546 children were assigned to one of the four designated blocks: 131 children were placed in block 1, 126 children in block 2, 125 children in block 3, and 164 children in block 4 (Table 6).

Table 6 BLOCKS OF CHILDREN BASED ON MAP-REASONING LEVEL SCORES AND DEFINED BY SCHOOL (Numbers of children)

YEAR	SCHOOL	BLOCKS			
		1 (2.50-2.75)	2 (2.76-3.00)	3 (3.01-3.25)	4 (3.26-3.50)
4	No. 1	37	23	10	4
	No. 2	23	11	9	1
5	No. 1	21	24	21	5
	No. 2	9	7	8	10
6	No. 1	17	24	11	8
	No. 2	7	6	11	12
7	No. 1	10	8	20	17
	No. 2	3	9	8	16
8	No. 3	4	6	14	40
9	No. 3	0	8	13	51
BLOCK TOTALS		131	126	125	164
TOTAL:		546 Children			

A final sample of 300 children was selected for the actual study. It was composed of 75 children from each of the four concrete map-reasoning blocks. Each group of 75 children was selected randomly from the number of children in the particular block by selecting their numbers out of a hat. Therefore, the actual study sample of 300 children was considered representative of the 600 + children in the study population.

The mean ages of the children in each block were computed when the four concrete map-reasoning blocks were organised. The results are recorded in Table 7.

Table 7 MEAN AGE OF CHILDREN IN EACH BLOCK (Years)

BLOCK	MEAN AGE (Years)
1	8.95
2	10.12
3	11.51
4	13.12

Table 7 indicates that the mean ages of the children in the blocks ascends from 8.95 years in block 1 to 13.12 years in block 4. Since Wilson (1979) and the investigator (1977) found no evidence of sex differences in Queensland children's mapping ability, the blocks were not differentiated according to sex.

3.30 Instrument development.

The main aims of this study are: (a) the development of competence and performance in cartographic language in children at the concrete level of map-reasoning, and (b) the investigation of some of the factors which influence children's map-reasoning,and competence and performance in cartographic language. The instruments used in this study reflect these aims.

The development of instruments occurred in four phases:

(i) the selection of a criterion reference related to cartographic communication,

(ii) the design of particular test instruments and the selection of standardised tasks,

(iii) the implementation of a limited pilot study to determine the extent and accuracy of the investigator - designed instruments, and

(iv) the tabulation of the final set of test instruments.

3.31 Selection of criterion reference.

The selection of a suitable criterion reference which was related to cartographic communication, but which was not one of the dependent variables, was difficult because of the limited amount of research into map users and cartographic communication. There is no Australian measure to serve this purpose. This study is concerned with the development of an ability in children. Therefore, a test linked to cognitive development would be an appropriate criterion reference. The map-reading test devised by Salomon and Feldman (1969) was selected as the criterion reference because it is concerned with maps and children's cognitive development as revealed in their map-reasoning levels.

This test consists of twenty-five map reading tasks arranged in a sequence of difficulty; the identification of stimuli, ikons and signs are located at the simple end of this sequence; the analysis of distance, heights, direction and abstract symbolism are located in the middle of the sequence; and interpretation based on inference, choice, decision-making and hypothesising are located at the complex end of the sequence. The seventeen multiple-choice items were selected from this range to measure the children's map-reasoning level. Each multiple-choice item consists of four options (one at each level of Piagetian cognitive development): (a) tautological/imaginary reasoning, (b) perceptual/

associative reasoning, (c)concrete reasoning, and (d) formal reasoning .

Following Salomon and Feldman's model, weightings are allotted to each of the four options, e.g. tautological X 1, perceptual X 2, concrete X 3 and formal X 4. Each child's map-reasoning level is calculated as the mean of his seventeen weighted scores:

$$\boxed{\text{Map Reasoning Level} = \frac{(\text{Tautological X } 1) + (\text{Perceptual X } 2) + (\text{Concrete X } 3) + (\text{Formal X } 4)}{\text{Number of items}}}$$

Children's map-reasoning level is a mean score which indicates that performance on this test is related to general reasoning development.

The purpose of this criterion reference was to enable the creation of four blocks of children based on their map-reasoning level. This study considered children at the concrete level of map-reasoning. They were children whose map-reasoning levels ranged from 2.5 to 3.5. The results of this test enabled the creation of four blocks containing similar numbers of children from which the final sample of 300 children was derived.

3.32 Range of test instruments.

The 300 children in the study sample undertook a wide range of tasks associated with:(a) their competence and performance in cartographic language, and (b) map design and map user factors which may influence their map-reasoning level, and their competence and performance in cartographic language. The instruments used in the study may be classified as investigator - designed instruments and standardised instruments.

The prime investigator-designed instrument was the test to measure children's competence in cartographic language. The investigator also devised instruments to measure the influence of the following factors on children's map-reasoning level, and their competence and performance in cartographic language: colour in cartographic signs, map generalisation, map lettering, home environment, previous experience with maps, understanding of the concept of a map, and attitudes to maps.

The test of children's competence in cartographic language was devised on the premise that the signs on the map and within its margins consist of:

(a) line, point and area signs presented in qualitative and quantitative forms;

(b) alphanumeric signs; and

(c) standard elements which are located around the margins of the map, e.g. scale and direction indicator. Alphanumeric signs were not examined separately. They were subsumed in the questions relating to the other signs listed above. This test consists of three subtests: the first two sub-tests are concerned with the qualitative presentation of line, point and area signs, and standard elements (Appendix 4), whilst the third subtest is concerned with the quantitative presentation of line, point and area signs (Appendix 5).

The sub-tests on qualitative cartographic signs and standard elements are based on two maps presented at a scale of 1:25,000: a coloured orthophotomap of Singleton (New South Wales) which is composed mainly of cartographic signals and a coloured topographic map of the same area which is composed of abstract cartographic symbols. The signs used in these sub-tests represented the range of line, point and area signs normally presented on maps (see Table 8).

Table 8 SELECTED QUALITATIVE CARTOGRAPHIC SIGNS USED IN COMPETENCE TEST

TYPE OF SIGN	EXAMPLES USED IN TEST
Line	Road River
Point	House Bridge
Area	Forest Town (Urban) Area

The quantitative cartographic signs used in the competence test were also representative of the range of line, point and area signs normally presented on maps. The questions in this sub-test focused on the type of sign, e.g. graded interval circles as a quantitative point sign, because there is less standardisation of quantitative cartographic signs. The signs for contour lines and layer tinting are universal and therefore exceptions to the above statement. Table 9 indicates the range of quantitative cartographic signs used in this study. The sign for contour lines was that used on the coloured orthophotomap. The map used for layer tinting was the map from the Salomon-Feldman map-reading test. The signs for the remaining quantitative cartographic signs were each based on a single prepared map so that one sign only dominated each map. Therefore, map user noise was minimised. The graded interval circle and the graded flow line signs are incorporated on separate maps on the research conclusions of Flannery (1971), Jenks (1970 and 1975), Jenks and Coulson (1963) and Meihofer (1969). For example, the radii of the graded interval circles are 1.99mm. 3.98mm, 7.98mm, 11.28mm and 15.96mm respectively. The horizontal bar sign is constructed on the basis of maximum discriminability. Bartz (1970) concluded that the scales on maps should commence at zero so that the children do not become confused. Therefore, the scale indicating the number of bicycles is drawn in the legend commencing at zero. The choropleth map illustrating the population density on Big Island is developed from research into shading by Jenks and Knos (1961). They concluded that the Williams' scale of percentage of inked area was clearest. This scale emphasised discrimination of shading at the extremes (the white and black areas) rather than being spread evenly across the grey scale (Williams, 1956 and 1958).

Table 9 SELECTED QUANTITATIVE CARTOGRAPHIC SIGNS USED IN COMPETENCE TEST.

TYPE OF SIGN	EXAMPLES USED IN TEST
Line	Contour Line Graded Flow Line
Point	Graded Interval Circle Horizontal Bar
Area	Density (Choropleth) Layer Tinting

Direction and scale are the standard elements selected for investigation. They are selected because of their integral roles in map use and interpretation.

Both the coloured orthophotomap and the coloured topographic map of Singleton are used for this purpose.

Each of the above signs or standard elements was investigated from the aspects of identification and comprehension. The research bases for these questions are the conclusions by Ryle (1956) and Soltis (1966) on successful seeing and personal communication with Evans (1977). Identification involves knowing the look of a sign, whilst comprehension involves understanding the sign and being able to make inferences about it.

The same arrangement of questions applied for each sign. It consists of:

a) the identification of the sign by drawing it in the relevant box, and

b) the comprehension of the sign by:

  (i) knowing the sign in context (i.e. on a map),

  (ii) knowing the sign out of context (i.e. in isolation),

  (iii) understanding the substantive concept represented by the sign, and

  (iv) making inferences about the sign.

The question on the children's knowledge of the sign out of context involved the children in writing a statement about the meaning of the sign. The remaining three parts of the comprehension question consisted of multiple-choice items involving a choice of one option in four.

Each question in the competence test carries a value of two marks. The children's scores were sub-totaled to determine scores on identification and comprehension for qualitative and quantitative cartographic signs, and standard elements. Total identification and comprehension scores, as well as a grand total score on children's competence in cartographic language, were derived from these sub-totals. The children were permitted approximately two hours to complete the whole competence test which was administered in three forty minute segments. Administrative procedures will be discussed later in Section 3.40 of this chapter.

The investigator devised three tests to measure the effects of map design on the map user: colour in cartographic signs (Appendix 6), map generalisation (Appendix 7), and map lettering (Appendix 8).

The test on colour in cartographic signs (Appendix 6) is a psychophysical one concerning the influence of colour on children decoding cartographic information. Coloured and black-and-white orthophotomaps and topographic maps of Singleton (New South Wales) presented at a scale of 1:25,000 are used in this test. The test consists of three parts:

(a) Part A focuses on the orthophotomaps,

(b) Part B focuses on the topographic maps, and

(c) Part C focuses on both coloured maps.

The questions in Parts A and B consist of similar structures : selection of the easier map to read; reasons for this selection; selection of features seen more clearly on each map; and questions involving the use of colour to read the map. The structure of the questions in Part C consists of: selection of the easier map to read; reasons for this selection; and questions concerning the placement of the signs for roads and trees. The questions are a blend of quantitative and subjective types aimed at measuring the influence of colour as well as the children's feelings towards its use. Therefore, the analysis of colour in cartographic signs consists of a score on the quantitative segments and frequency counts on the subjective observations. The children were permitted approximately forty minutes to complete this task.

The map generalisation test (Appendix 7) was devised to ascertain the effect of generalisation on cartographic information perceived and decoded by the map user. Two sets of maps are used in this test: (a) set 1 consists of two coloured topographic maps of Beenleigh (Queensland) presented at scales of 1:25,000 and 1:100,000 respectively, and (b) set 2 consists of two orthophotomaps - the Petrie map sheet presented at a scale of 1:2500 and the Caboolture map sheet presented at a scale of 1:10,000. The study area for the maps in set 1 consists of the whole of the 1:25,000 map and the small, delimited central area of the 1:100,000 map. The study area for the maps in set 2 consists of the whole of the 1:2500 Petrie orthophotomap and the small, delimited central area of the 1:10,000 Caboolture orthophotomap. The maps in set 1 emphasise cartographic symbols, whilst those in set 2 emphasise cartographic signals.

The actual test is subdivided into four parts - one for each map. A range of comparable questions was developed for comparable features in each set of maps. Some of the questions on the smaller scale maps are difficult to answer because of the amount of generalisation the cartographer employed as the scale changed. Finally, the children were asked questions concerning their perceptions of the signs for roads and buildings.

All of the questions in this test, except for the questions on the children's perception of roads and buildings, are quantifiable. Therefore, the children's total score on the four maps represents their understanding of map generalisation. The children were permitted approximately thirty-five minutes to complete this test.

The children's perceptions of the position of lettering on a map were tested in the map-lettering test (Appendix 8). Two maps were drawn on the basis of Imhof's numerous, precise statements on the positioning of letters on a map. The map of Island X encompasses a range of correct aspects of map lettering. The map of Island Y encompasses many of the incorrect aspects. Both maps are presented in black-and-white form in order to eliminate any influence colour may have on the results. The differentiation of land from water is simple, but clear, on both maps. Variation in type size and style occurs on the correct map (Island X).

The test consists of two quantifiable segments (Parts A and B) and a subjective segment (Part C). The questions in Parts A and B are parallel questions designed to determine whether poor placement of map lettering influences the accuracy of children's responses. Each correct response in Parts A and B scores one mark. Their total scores on Parts A and B represent the children's scores concerning the influence of map lettering. Part C was included to encourage the children to verbalise on the influence of the lettering on their ability to read maps. Frequency counts were made of the responses in Part C to generalise why the children found the map of Island X easier to read. The children were permitted approximately thirty minutes to complete this task.

The remaining investigator-designed instruments are concerned with characteristics of the map user. They consist of tests of the children's understanding of the concept of a map and of their attitudes to maps, as well as surveys of their home environment and their previous experiences with maps.

The test of the children's understanding of the concept of a map (Appendix 9) was a brief task based on their ability to : verbalise what a map is; distinguish maps from non-maps; and to know why the examples they select are maps. The verbalising question consists of the children writing their definition of a map. The identification of maps consists of the children selecting maps from six possible extracts which they view. Finally, the children are asked to reason why the extracts they select are maps. The children's map concept score is the total of their scores on the three segments of the task. Children were permitted approximately twenty minutes to complete this task.

Children's attitudes to maps are subjective by nature. Therefore, they are difficult to measure. Petchenik (1974) used Osgood's theory on the use of the semantic differential technique (1967) to measure children's attitudes to the overall look of maps. She concluded that the five general map characteristics of attitudes to maps which can be examined are: (a) spatial characteristics, (b) texture, (c) light, (d) data quality impressions, and (e) emotional reactions. The attitudinal test in this study (Appendix 10) examined each of the five general map characteristics. Four word-pairings are used for each general map characteristic. Children were asked to examine four coloured map extracts and to record their feelings on a five-point semantic scale. The children were scored for each response on a +2 to -2 range with 0 being the neutral response. The children's score on this test is the summation of their positive and negative scores. The children were permitted approximately twenty minutes to complete this task.

Children's previous experiences with maps, or map-associated activities, influence their understanding of maps and the language used on maps. Research by Blaut and Stea (1971) and Dale (1971), and the observations by Wilson (1978) confirm this statement. A survey has been devised to measure children's previous experiences with maps. The 21 statements in the survey are arranged in three sub-groups: (a) membership of clubs or groups using maps or mapping techniques , (b) personal experiences which could involve the use of maps, and (c) previous use of maps in formal educational settings. The 21 statements consist of twenty statements which are answered by ticking a "yes" box or a "no" box and one question which is answered by recording the name of an activity. "Yes" responses receive a score of 1 and "no" answers receive a score of 0. The children's score on the task was the summation of their scored responses (see Appendix 11).

A survey of the children's home environments was the final investigator-designed instrument (Appendix 12). The investigator suspected that children from homes where maps are abundant and where a parent is a surveyor or a geographer,bring enriching environmental experiences to the map use and design situations. The Central Advisory Council for Education in England conducted the 1964 National Survey of Parental Attitudes and Circumstances Related to School and Pupil Characteristics. Their report (1967) provided the basis for this survey on children's home environments. It focuses on five aspects: (a) literacy in the home, (b) parental involvement and interest in education, (c) home experiences, (d) parental occupation, and (e) physical characteristics of the home environment. Literacy in the home focuses on parental reading and library habits; the presence of books containing maps in the home; and children's reading of publications containing maps. Parental involvement in education is concerned with parents' attitude to education at home and at school. Home experiences which incorporate spatial activities are included, e.g. puzzles, television and radio. Parental occupation is the highest ranked occupation of either parent. The occupations are subdivided into four groups according to the skill and level of training necessitated by the occupation: professional and managerial occupations rate 4; sales and clerical occupations 3; skilled trade occupations 2; and unskilled or semi-skilled occupations rate 1. Questions on the physical nature of the home environment focus on a description of its qualities, the children's knowledge of their environment and whether they live in tall buildings. Most questions are answered by ticking a "yes" box or a "no" box. "Yes" responses received a score of 1 and "no" answers a score of 0. The question on hours of television viewed daily was scored on a sliding scale where a response of "1-2 hours" received a score of 4 and "none" received a score of 0. The question on a description of the child's physical home environment was scored on a four-point scale with a score of 4 for an environment of new houses with a great deal of landscaping and trees, and a score of 1 for an aged environment of dilapidated houses with minimal landscaping. The question on the children's movement around their neighbourhood was also scored on a four-point scale: "walk" scores 4, "bicycle" 3; "car" 2; and"public transport" scores 1. The home environment index is the summation of each child's score on the 31 questions. The children were permitted approximately twenty-five minutes to answer this survey.

The standardised tests used in this study were derived from American and Australian sources. American tests were used to measure children's performance in cartographic language, drawing ability, and map-reading ability.

Children's performance in cartographic language was measured by their ability to draw a map of their school grounds in approximately thirty-five minutes. The children's maps were scored on the basis of Snyder, Feldman and La Rossa's manual for a Piaget-based map-drawing exercise (1975). The focal points in this manual are the sequences of six levels of spatial reasoning development for arrangement, proportion, perspective (orthogonal view), and language. These levels are scored on a scale from 1 to 6, with 1 being the score for level one and 6 being the score for level six. This study is concerned only with the language used on maps. Therefore, the children's score on their performance in cartographic language was their score out of 6 on the language scale as rated by two map experts.

Children's drawing ability was measured using Eisner's fourteen point visual and verbal scale (1967). These categories encapsulate the developmental aspects of children's drawing ability (see Appendix 13). There are thirteen actual categories and one miscellaneous grouping. The thirteen categories range from number one in which the children do not draw a horizon line and morphemes (figures) appear to float around the drawing, to number thirteen in which the children draw the horizon line and present morphemes overlapping each other. Specialists in art education used Eisner's scale to score the children's drawings. The drawings assigned to category one received a score of 1 and those assigned to category thirteen received a score of 13. The raters had at least one practice scoring session before they scored the children's drawings.

The map reading test (W-1) from the Iowa Tests of Basic Skills - Forms 5 and 6 (1974) was used to measure the children's map-reading ability. This test is based on the suggested use of maps and globes in chapter nine of the Thirty-Third Yearbook of the National Council for Social Studies (Carpenter, 1963), as well as map skills sequences suggested by Anderzhon (1955), Hanna et al. (1966) and Harris (1967). This test is based on the following eight map skills:

(a) orientation of a map and determination of direction,

(b) location and/or description of places on maps and globes,

(c) determination of distances,

(d) determination of routes of travel,

(e) understanding seasonal variations, sun patterns and time differences,

(f) reading and comparison of facts from one or more pattern maps,

(g) visualisation of landscape features, and

(h) inferences of man's activities or way of living.

(Hieronymus and Lindquist, 1971:44)

Tests at different levels are presented to children aged from approximately nine years to fourteen years. Children answer a range of multiple-choice questions (e.g. 42 for children in Level 14) in a time span of approximatlely thirty minutes. The children's raw scores may be standardised or converted into developmental scores (termed grade-equivalents or age equivalents) or status scores (percentile ranks, standard scores or stannines). The test questions are scaled in difficulty and number so that the older children are required to complete the most questions and the most difficult questions. In this study, the children's raw scores were converted to percentages since the American norms may not be valid for Queensland children.

The Australian standardised tests in this study consisted of the Jenkins Nonverbal Test(adapted by the Australian Council for Educational Research from the British test of the same name), the A.C.E.R. Intermediate Test A and A.C.E.R. Space Test.

The Jenkins Nonverbal Test was used to test the children's nonverbal intelligence. It consists of eighty nonverbal items of a diagrammatic type which are sub-divided into five sub-tests of almost equal length.

Items in each sub-test are arranged in ascending order of difficulty. Each sub-test is preceded by a worked example of the principle involved in that sub-test: sub-tests one and three focus on classification; sub-tests two and four on serial order; and sub-test five focuses on diagrammatic analogies. Children were permitted to spend approximately thirty minutes on the test. The established norms for this test are for children aged from ten years to fourteen years. The children in the study group were of ages which extended beyond either end of the normed age range. Therefore, IQ scores were extrapolated from the existing normed scores using program REGEN provided by the Research Branch of the Queensland Education Department. These extrapolations extended down to children aged 8.0 years and up to children aged 15.0 years. The children's raw scores were converted to IQ scores on the basis of the norms supplied in the test manual (A.C.E.R., 1973).

The A.C.E.R. Intermediate Test A was used to measure the children's verbal intelligence. It consists of eighty items which are arranged in ascending order of difficulty. The items include classifications, jumbled sentences, synonyms and antonyms, number series, verbal and arithmetic problems and assigning meanings to proverbs. Practice questions for each type of task precede the particular items. Normed IQ scores are established for children aged ten years through fourteen years. As for the Jenkins Nonverbal Test, program REGEN was used to extrapolate the IQ scores down to 8.0 years and up to 15.0 years. Their raw scores were converted to IQ scores using the conversion tables in the test manual (A.C.E.R., 1964).

The A.C.E.R. Space Test (1978a) from the A.C.E.R. Mathematics Profile Series was used to measure children's spatial ability. This test is designed for use with children aged 8+ years and upwards. It covers a graded range of content areas and process objectives which are arranged carefully through its four levels. Its content areas consist of four groups: (a) basic concepts, perception and topology; (b) location, distance and angular relations; (c) properties and relations of solids and shapes; and (d) spatial transformations. The process objectives are three fold: (a) basic processes - knowledge of concepts, operations, classification and ordination; (b) understanding processes - communication, relevance and interpretation; and (c) application processes - problem-solving, reasoning and cognitive aspects of creativity. The children were permitted to spend approximately thirty minutes working on the test. Their raw scores were converted to standardised scores by the Rasch method (1966) which is the basis of the MAPS measurement scale. This scale converts the children's raw scores into standardised units - brytes (the higher the children's spatial ability the higher the number of brytes). The MAPS scale is centred arbitrarily on fifty brytes since this represents the children's level of spatial development at the primary - secondary transition (A.C.E.R., 1978 b: 2).

3.33 Pilot study.

A pilot study was conducted in June, 1978, to gain insight into the problem and to examine the children's understanding of the investigator - designed tests. It was used to determine the most suitable language for the questions in the tests and surveys; the ambiguity of any questions; and the appropriateness of the length of the tests and surveys. In effect, the pilot study was conducted to seek evidence of the reliability of the tests.

The sample of children who experienced the pilot consisted of twenty children - ten from Year 5 (mean age 9.8 years) and ten from Year 8 (mean age 12.97 years). These children were selected in age ranges approximating the extremes of the study group's age range. These children live in similar geographical areas to the children in the study group.

Three methods were used to examine the investigator - designed tests: (a) an item analysis of the test questions; (b) an analysis of item difficulty; and (c) subjective analyses based on the children's comments.

Item analyses were computed for the three sub-tests on children's competence in cartographic language. They revealed that for qualitative cartographic signs and standard elements on maps A and B:

(a) the group mean scores for all questions except for comprehension questions relating to the signs for roads (both maps), bridge (both maps), and urban area (map B), were acceptable,

(b) the group mean scores for children in Year 5 were generally lower than those for children in Year 8, indicating improved performance with age (see Tables 10 and 11), and

(c) there was a sequence of increased difficulty in comprehension questions for each sign. This sequence began with knowledge of the sign in and out of context and progressed through understanding the substantive concept to the ability to make inferences about the sign.

Table 10 CHILDREN'S COMPETENCE IN CARTOGRAPHIC SIGNS (MAP A) - ITEM ANALYSIS

QUESTION	MARKS	$\bar{X}$ GROUP	SD GROUP	$\bar{X}_5$	SD_5	$\bar{X}_8$	SD_8
A. (i)	2	1.4	0.75	1.1	0.87	1.7	0.48
(ii) a	2	1.4	0.68	1.3	0.67	1.5	0.71
b	2	1.1	1.02	1.2	1.03	1.0	1.05
c	2	1.5	0.88	1.4	0.96	1.6	0.84
d	2	1.8	0.62	1.6	0.84	2.0	0.00
B. (i)	2	1.3	0.98	0.6	0.97	2.0	0.00
(ii) a	2	0.8	1.00	0.4	0.84	1.2	1.00
b	2	1.3	0.98	1.4	0.96	1.2	1.00
c	2	1.4	0.94	1.4	0.97	1.4	0.97
d	2	0.9	1.00	1.0	1.10	0.8	1.00
C. (i)	2	1.8	0.62	1.6	0.84	2.0	0.00
(ii) a	2	1.45	0.60	1.0	0.47	1.9	0.32
b	2	0.3	0.73	0.2	0.63	0.4	0.84
c	2	0.8	1.00	1.0	1.10	0.6	0.97
d	2	1.4	0.94	1.2	1.00	1.6	0.84
D. (i)	2	1.6	0.82	1.2	1.00	2.0	0.00
(ii) a	2	1.4	0.68	0.2	0.63	1.8	0.63
b	2	1.7	0.73	1.6	0.84	1.8	0.63
c	2	1.9	0.45	1.8	0.63	2.0	0.00
d	2	0.8	1.00	1.2	1.00	0.4	0.84
E. (i)	2	1.9	0.45	1.8	0.63	2.0	0.00
(ii) a	2	1.3	0.66	1.0	0.47	1.6	0.69
b	2	1.7	0.73	1.6	0.84	1.8	0.63
c	2	1.1	1.00	0.4	0.84	1.8	0.63
d	2	0.9	1.00	1.2	1.00	0.6	0.96

Table 10 continued)

F. (i)	2	1.85	0.37	1.4	0.96	2.0	0.00
(ii) a	2	1.45	0.6	1.0	0.47	1.9	0.32
b	2	1.6	0.82	1.4	0.96	1.8	0.63
c	2	1.0	1.00	1.4	0.97	0.6	0.97
d	2	0.3	0.73	0.4	0.84	0.2	0.63
G. (i)	2	1.85	0.49	1.7	0.67	2.0	0.00
(ii) a	2	1.5	0.69	1.1	0.74	1.9	0.32
b	2	1.8	0.62	1.8	0.62	1.8	0.62
c	2	1.4	0.94	0.8	1.00	2.0	0.00
d	2	1.4	0.94	1.0	1.05	1.8	0.63
H. (i)	2	1.3	0.92	0.6	0.84	2.0	0.00
(ii) a	2	1.1	1.00	0.4	0.84	1.8	0.63
b	2	1.2	1.00	1.2	1.00	1.2	1.00
c	2	1.0	1.00	0.8	1.00	1.2	1.00
d	2	0.9	1.00	0.4	0.84	1.4	0.97

Table 11 CHILDREN'S COMPETENCE IN CARTOGRAPHIC SIGNS (MAP B) - ITEM ANALYSIS

QUESTION	MARKS	$\bar{X}$ GROUP	SD GROUP	$\bar{X}_5$	SD_5	$\bar{X}_8$	SD_8
A (i)	2	1.25	0.79	1.0	0.94	1.5	0.53
(ii) a	2	1.30	0.73	1.0	0.67	1.5	0.53
b	2	1.20	1.00	1.0	1.00	1.4	0.97
c	2	1.20	1.00	0.8	1.00	1.6	0.84
d	2	1.70	0.73	1.8	0.63	1.6	0.84
B. (i)	2	1.50	0.76	0.9	0.74	2.0	0.00
(ii) a	2	1.00	0.83	0.5	0.71	1.6	0.52
b	2	1.10	1.00	1.2	1.00	1.0	1.10
c	2	1.10	1.00	1.2	1.00	1.0	1.10
d	2	1.00	1.00	1.0	1.00	1.0	1.10
C. (i)	2	1.60	0.82	1.2	1.00	2.0	0.00
(ii) a	2	1.20	0.77	0.8	0.63	1.6	0.69
b	2	0.70	0.98	0.8	0.63	0.6	0.97
c	2	0.90	1.00	0.8	1.00	1.0	1.10
d	2	1.60	0.82	1.4	0.97	1.8	0.63
D. (i)	2	1.80	0.62	1.6	0.84	2.0	0.00
(ii) a	2	1.20	0.87	0.4	0.84	1.4	0.97
b	2	1.60	0.82	1.4	0.97	1.8	0.63
c	2	1.70	0.73	1.6	0.84	1.8	0.63
d	2	1.00	1.00	1.2	1.00	0.8	1.00
E. (i)	2	1.60	0.68	1.0	1.10	1.8	0.97
(ii) a	2	1.30	0.85	0.8	0.79	1.7	0.67
b	2	1.50	0.89	1.2	1.00	1.8	0.63
c	2	1.00	1.00	0.8	1.00	1.0	1.10
d	2	1.20	1.00	1.2	1.00	1.2	1.00
F. (i)	2	1.60	0.58	1.0	1.00	1.8	0.63
(ii) a	2	1.20	0.89	0.6	0.69	1.8	0.63
b	2	1.40	0.94	1.0	1.00	1.8	0.63

Table 11 Cont.

c	2	1.30	0.98	1.4	0.97	1.2	1.00
d	2	0.20	0.62	0.2	0.63	0.2	0.63
G. (i)	2	1.5	0.69	1.1	0.74	2.0	0.00
(ii) a	2	1.25	0.79	0.9	0.57	1.6	0.84
b	2	1.60	0.82	1.2	1.0	2.0	0.00
c	2	1.40	0.94	1.0	1.10	1.8	0.63
d	2	1.00	1.00	0.6	0.97	1.4	0.97
H. (i)	2	1.10	0.89	0.5	0.85	1.2	1.00
(ii) a	2	0.95	0.95	0.5	0.85	1.5	0.71
b	2	0.70	0.98	0.5	0.85	1.0	1.10
c	2	0.50	0.89	0.5	0.85	0.6	0.97
d	2	0.70	0.98	0.5	0.85	1.0	1.10

The item difficulty of questions is the proportion of correct answers for each question. The analyses of item difficulty for questions concerning qualitative cartographic signs and standard elements on maps A and B revealed that:

(a) the most difficult items were the comprehension questions related to the signs for bridge (Question F.iid), road(C.iib and C.iic), river(D.iid) and urban area (Question H.ii), and

(b) children in Year 5 experienced greater difficulty than those in Year 8. These conclusions indicated that identification of cartographic signs was easier than their comprehension. It also indicated that questions discriminated amongst the children according to their age - Year 8 children displayed greater evidence of competence in cartographic language than Year 5 children (see Tables 12 and 13).

Table 12 CHILDREN'S COMPETENCE IN CARTOGRAPHIC SIGNS

(MAP A) - ITEM DIFFICULTY

QUESTION	GROUP	YEAR 5	YEAR 8
A (i)	0.55	0.4	0.7
(ii) a	0.50	0.4	0.6
b	0.55	0.6	0.5
c	0.75	0.7	0.8
d	0.90	0.8	1.0
B (i)	0.65	0.3	1.0
(ii) a	0.40	0.2	0.6
b	0.65	0.7	0.6
c	0.70	0.7	0.7
d	0.45	0.5	0.4
C (i)	0.90	0.8	1.0
(ii) a	0.50	0.1	0.9
b	0.15	0.1	0.2
c	0.40	0.5	0.3
d	0.70	0.6	0.8
D. (i)	0.80	0.6	1.0
(ii) a	0.50	0.1	0.9
b	0.85	0.8	0.9
c	0.95	0.9	1.0
d	0.40	0.6	0.2
E. (i)	0.95	0.9	1.0
(ii) a	0.40	0.1	0.7
b	0.85	0.8	0.9
c	0.55	0.2	0.9
d	0.45	0.6	0.3
F (i)	0.85	0.7	1.0
(ii) a	0.50	o.1	0.9
b	0.80	0.7	0.9
c	0.50	0.7	0.3
d	0.15	0.2	0.1
G (i)	0.90	0.8	1.0
(ii) a	0.60	0.3	0.9
b	0.90	0.9	0.9
c	0.70	o.4	1.0
d	0.70	0.5	0.9
H (i)	0.60	0.2	1.0
(ii) a	0.55	0.2	0.9
b	0.60	0.6	0.6
c	0.50	0.4	0.6
d	0.45	0.2	0.7

Table 13 CHILDREN'S COMPETENCE IN CARTOGRAPHIC SIGNS (MAP B) - ITEM DIFFICULTY.

QUESTION			GROUP	YEAR 5	YEAR 8
A	(i)		0.45	0.4	0.5
	(ii)	a	0.45	0.2	0 7
		b	0.60	0.5	0.7
		c	0.60	0.4	0.8
		d	0.85	0.9	0.8
B	(i)		0.60	0.2	1.0
	(ii)	a	0.35	0.1	0.6
		b	0.55	0.6	0.5
		c	0.55	0.6	0.5
		d	0.50	0.5	0.5
C	(i)		0.80	0.6	1.0
	(ii)	a	0.40	0.1	0.7
		b	0.35	0.4	0.3
		c	0.45	0.4	0.5
		d	0.80	0.7	0.9
D	(i)		0.90	0.8	1.0
	(ii)	a	0.45	0.2	0.7
		b	0.80	0.7	0.9
		c	0.85	0.8	0.9
		d	0.50	0.6	0.4
E	(i)		0.70	0.5	0.9
	(ii)	a	0.50	0.2	0.8
		b	0.75	0.6	0.9
		c	0.50	0.4	0.6
		d	0.60	0.6	0.6
F	(i)		0.70	0.5	0.9
	(ii)	a	0.50	0.1	0.9
		b	0.70	0.5	0.9
		c	0.65	0.7	0.6
		d	0.10	0.1	0.1
G	(i)		0.65	0.3	1.0
	(ii)	a	0.45	o.1	0.8
		b	0.80	0.6	1.0
		c	0.70	0.5	0.9
		d	0.50	0.3	0.7
H	(i)		0.40	0.2	0.6
	(ii)	a	0.40	0.2	0.6
		b	0.35	0.2	0.5
		c	0.25	0.2	0.3
		d	0.35	0.2	0.5

The item analysis of the questions in the sub-test on children's competence in quantitative cartographic signs (Table 14) revealed that:

(a) the group mean scores on all questions were acceptable,

(b) children in Year 8 achieved higher mean scores on most questions, and

(c) the differences between the mean scores of children in Years 5 and 8 were less for quantitative signs than for qualitative signs. This suggests that the questions on qualitative cartographic signs were more discriminating than those on quantitative cartographic signs.

The analysis of the item difficulty of questions on quantitative signs (Table 15) revealed that:

(a) children experienced most difficulty comprehending contour lines (Section A),

(b) children in Year 5 generally found the items more difficult than children in Year 8 (i.e. there was a degree of discrimination across the Years), and

(c) the differences in item difficulty between children in Years 5 and 8 was less than for qualitative cartographic signs.

Table 14 CHILDREN'S COMPETENCE IN QUANTITATIVE CARTOGRAPHIC SIGNS - ITEM ANALYSIS

QUESTIONS			MARKS	$\bar{X}_{GROUP}$	SD_{GROUP}	$\bar{X}_5$	SD_5	$\bar{X}_8$	SD_8
A	(i)		2	1.45	0.76	1.1	0.88	1.8	0.42
	(ii)	a	2	1.15	0.75	0.9	0.74	1.4	0.69
		b	2	1.30	0.98	0.4	0.97	1.5	0.71
		c	2	0.90	1.00	0.5	0.85	1.4	0.97
		d	2	1.00	1.00	1.1	0.88	1.5	0.71
B	(i)		2	1.60	0.50	1.2	0.42	2.0	0.00
	(ii)	a	2	1.40	0.59	1.3	0.48	1.4	0.70
		b	2	2.00	0.00	2.0	0.00	2.0	0.00
		c	2	1.20	1.00	1.4	0.69	1.4	0.97
		d	2	1.40	0.94	1.5	0.71	1.8	0.42
C	(i)		2	1.60	0.5	1.2	0.42	2.0	0.00
	(ii)	a	2	1.60	0.67	1.8	0.42	1.7	0.48
		b	2	1.70	0.73	2.0	0.00	1.7	0.48
		c	2	1.50	0.89	1.5	0.71	1.8	0.63
		d	2	1.20	1.00	1.4	0.69	1.7	0.48
D	(i)		2	1.45	0.69	1.1	0.56	1.8	0.63
	(ii)	a	2	1.60	0.69	1.4	0.85	1.7	0.48
		b	2	1.80	0.62	1.8	0.63	1.8	0.63
		c	2	1.50	0.89	1.0	1.10	2.0	0.00
		d	2	1.20	1.00	1.1	0.88	1.8	0.42
E	(i)		2	1.40	0.75	1.0	0.67	1.7	0.67
	(ii)	a	2	1.10	0.89	0.9	0.99	1.2	0.79
		b	2	1.50	0.89	1.8	0.42	1.7	0.48
		c	2	1.50	0.89	1.5	0.71	1.8	0.63
		d	2	1.70	0.73	1.8	0.63	1.8	0.42
F	(i)		2	1.70	0.47	1.4	0.52	2.0	0.00
	(ii)	a	2	1.45	0.69	1.2	0.63	1.7	0.67
		b	2	1.90	0.45	1.8	0.63	2.0	0.00
		c	2	1.50	0.89	1.4	0.97	1.7	0.67
		d	2	1.20	1.00	1.2	1.00	1.2	1.00

Table 15 CHILDREN'S COMPETENCE IN QUANTITATIVE CARTOGRAPHIC SIGNS - ITEM DIFFICULTY.

QUESTION			GROUP	YEAR 5	YEAR 8
A	(i)		0.60	0.4	0.8
	(ii)	a	0.35	0.2	0.5
		b	0.65	0.7	0.6
		c	0.45	0.2	0.7
		d	0.50	0.4	0.6
B	(i)		0.60	0.2	1.0
	(ii)	a	0.40	0.3	0.5
		b	1.00	1.0	1.0
		c	0.60	0.5	0.7
		d	0.70	0.6	0.8
C	(i)		0.60	0.2	1.0
	(ii)	a	0.75	0.8	0.7
		b	0.85	1.0	0.7
		c	0.75	0.6	0.9
		d	0.60	0.5	0.7
D	(i)		0.55	0.2	0.9
	(ii)	a	0.65	0.6	0.7
		b	0.90	0.9	0.9
		c	0.75	0.5	1.0
		d	0.60	0.4	0.8
E	(i)		0.50	0.2	0.8
	(ii)	a	0.40	0.4	0.4
		b	0.75	0.8	0.7
		c	0.75	0.6	0.9
		d	0.85	0.9	0.8
F	(i)		0.70	0.4	1.0
	(ii)	a	0.55	0.3	0.8
		b	0.95	0.9	1.0
		c	0.75	0.7	0.8
		d	0.60	0.6	0.6

The above analysis indicated that the three sub-tests on children's competence in cartographic language were discriminating tests containing items of a suitable standard for children in the study group age range. The children experienced no difficulty in reading the test questions. They appreciated the practice questions which prefaced the qualitative signs' sub-tests. The children experienced no difficulty following the directions included with each question. Therefore, the tests on children's competence in cartographic language were found to be suitable for use with the study group.

Three investigator-designed tests on map design variables were tested in the pilot study : (a) colour in cartographic signs ;(b) map generalisation;and (c) map lettering.

The test on colour examined children's perception and understanding of signs on coloured and black-and-white orthophotomaps and topographic maps (Appendix 6). The item analysis of the children's responses (Table 16) and the analysis of item difficulty (Table 17) revealed that:

(a) there was limited discrimination between children in years 5 and 8 in regard to colour in cartographic signs, and

(b) items B5, A5 and A7, which sought children's interpretation and discrimination of objects on black-and-white maps, exhibited greatest item difficulty and lowest group mean scores. The children found that comparable questions on the coloured maps (B6, A6 and A8) were easier to answer.

Table 16 COLOUR ON CARTOGRAPHIC SIGNS - ITEM ANALYSIS

QUESTION	MARKS	$\bar{X}$ GROUP	SD GROUP	$\bar{X}_5$	SD_5	$\bar{X}_8$	SD_8
A. 5	1	0.45	0.51	0.2	0.43	0.7	0.48
6	1	0.75	0.44	0.8	0.42	0.7	0.48
7	1	0.45	0.51	0.4	0.52	0.5	0.53
8	1	0.70	0.47	0.7	0.48	0.7	0.48
9	1	0.55	0.51	0.6	0.52	0.5	0.53
10	1	0.60	0.50	0.5	0.53	0.7	0.48
B. 5	1	0.30	0.47	0.3	0.48	0.3	0.48
6	1	0.65	0.49	0.6	0.52	0.7	0.48
7	1	0.65	0.49	0.7	0.48	0.6	0.52
8	1	0.65	0.49	0.5	0.53	0.8	0.42

Table 17 COLOUR ON CARTOGRAPHIC SIGNS - ITEM DIFFICULTY

QUESTION	GROUP	YEAR 5	YEAR 8
A.5	0.45	0.2	0.7
6	0.75	0.8	0.7
7	0.45	0.4	0.5
8	0.70	0.7	0.7
9	0.55	0.6	0.5
10	0.60	0.5	0.7
B.5	0.30	0.3	0.3
6	0.65	0.6	0.7
7	0.65	0.7	0.6
8	0.65	0.5	0.8

The remaining questions on the colour test required subjective responses from the children. The children did not report any difficulty with the verbal language used in these questions. The quality of their reasons for selecting coloured maps varied according to age - the older children provided more detailed and less egocentric reasons.

The map generalisation test examined children's understanding of the effect of generalisation on cartographic information (Appendix 14). The item analysis (Table 18) revealed that children had most difficulty with the questions on local relief (Q.3) and the location of the shopping centre (Q. 4) on both topographic maps of Beenleigh. The analysis of item difficulty (Table 19) reinforced this conclusion. There was little discrimination between the performances of children in Years 5 and 8 on question four. Therefore, it was omitted from the final test instrument on map generalisation. The children had most difficulty on the orthophotomaps with the questions on the road-rail intersection (Q. 3) and local relief (Q. 4). They recorded a mean score of 1.1 on question three and mean scores of 0.55 and 0.75 on question four. There was better discrimination between the children in Years 5 and 8 on question three. Therefore, question four was omitted from the questions on the orthophotomaps in the final test instrument.

The final two questions in each section of the test asked the children to comment on the following statements:

(a) "The road signs on the map show the true road position and size".

(b)"The outlines of buildings on the map show their true size and shape".

The children answered these questions poorly because they confused either position and size or size and shape. Their responses lacked discrimination across the Years. Therefore, these questions were deleted from the final test.

Table 18 CHILDREN'S UNDERSTANDING OF MAP GENERALISATION - ITEM ANALYSIS

QUESTION	MARKS	$\bar{X}_{GROUP}$	SD_{GROUP}	$\bar{X}_5$	SD_5	$\bar{X}_8$	SD_8
A. 1	2	2.00	0.00	2.0	0.00	2.0	0.00
2	2	1.75	0.55	1.9	0.32	1.6	0.69
3	2	0.65	0.81	0.5	0.85	0.8	0.79
4	1	0.30	0.47	0.3	0.47	0.3	0.47
5	1	0.85	0.36	0.9	0.32	0.8	0.42
6	1	0.70	0.47	0.9	0.32	0.5	0.52
7	1	0.55	0.51	0.6	0.52	0.5	0.52
B. 1	2	2.00	0.00	2.0	0.00	2.0	0.00
2	2	1.65	0.58	1.5	0.70	1.8	0.42
3	2	0.60	0.75	0.5	0.70	0.7	0.82
4	1	0.25	0.44	0.2	0.42	0.3	0.48
5	1	0.85	0.37	0.9	0.32	0.8	0.42
6	1	0.40	0.50	0.4	0.52	0.4	0.52
7	1	0.50	0.52	0.5	0.52	0.5	0.52
C. 1	1	0.95	0.22	0.9	0.32	1.0	0.00
2	2	1.50	0.69	1.2	0.79	1.8	0.42
3	2	1.10	0.44	1.0	0.47	1.2	0.42
4	2	0.55	0.75	0.8	0.78	0.3	0.67
5	1	0.40	0.50	0.3	0.48	0.4	0.51
6	1	0.85	0.37	0.8	0.42	0.9	0.32
7	1	0.65	0.48	0.6	0.52	0.7	0.48
8	1	0.90	0.31	0.8	0.42	1.0	0.00
D. 1	1	0.95	0.22	1.0	0.00	0.9	0.32
2	2	1.30	0.73	1.0	0.66	1.6	0.69
3	2	1.15	0.37	1.1	0.32	1.2	0.42
4	2	0.75	0.72	0.7	0.67	0.8	0.79
5	1	0.30	0.47	0.3	0.47	0.3	0.47
6	1	0.50	0.51	0.3	0.48	0.7	0.48
7	1	0.75	0.44	0.9	0.32	0.6	0.52
8	1	0.60	0.50	0.5	0.52	0.7	0.48

Table 19 CHILDREN'S UNDERSTANDING OF MAP GENERALISATION - ITEM DIFFICULTY

QUESTION		GROUP	YEAR 5	YEAR 8
A.	1	1.00	1.0	1.0
	2	0.80	0.9	0.7
	3	0.20	0.2	0.2
	4	0.30	0.3	0.3
	5	0.85	0.9	0.8
	6	0.7	0.9	0.5
	7	0.55	0.6	0.5
B.	1	1.00	1.0	1.0
	2	0.70	0.6	0.8
	3	0.15	0.1	0.2
	4	0.25	0.2	0.3
	5	0.85	0.9	0.8
	6	0.40	0.4	0.4
	7	0.50	0.5	0.5
C.	1	0.95	0.9	1.0
	2	0.60	0.4	0.8
	3	0.15	0.1	0.2
	4	0.15	0.2	0.1
	5	0.40	0.3	0.5
	6	0.85	0.8	0.9
	7	0.65	0.6	0.7
	8	0.90	0.8	1.0
D.	1	0.95	1.0	0.9
	2	0.55	0.2	0.7
	3	0.15	0.1	0.2
	4	0.15	0.1	0.2
	5	0.30	0.3	0.3
	6	0.50	0.3	0.7
	7	0.75	0.9	0.6
	8	0.60	0.5	0.7

The children experienced less difficulty on the map lettering test (Appendix 8). The item analysis (Table 20) and the analysis of item difficulty (Table 21) revealed that the children experienced most difficulty with the purposely confusing map of Island Y, especially with questions six and nine. This difficulty was not evident on the neat, accurate map of Island X. These questions were similar for both maps. Therefore, they are retained in the final test instrument. The remaining items did not cause the children any difficulties. The children did not express any difficulty with the verbal language used in the test questions. The items also indicated some discrimination in the responses of children in Years 5 and 8.

The final test used in the pilot study was that concerned with the children's understanding of the concept of a map (Appendix 9). The children did not express any difficulty with the verbal language of the questions and the range of maps and aerial photographs. However, few children achieved maximum scores. The item analysis (Table 22) indicated reasonable group mean scores. The analysis of item difficulty (Table 23) indicated that the children found all questions difficult to achieve maximum marks. There was also some discrimination between the scores of children in Years 5 and 8. Consequently, the test was retained in its original form.

Table 20 CHILDREN'S UNDERSTANDING OF THE POSITIONING OF MAP LETTERING - ITEM ANALYSIS

QUESTION	MARKS	$\overline{X}$ GROUP	SD GROUP	$\overline{X}_5$	SD_5	$\overline{X}_8$	SD_8
A. 1	1	0.60	0.50	0.5	0.53	0.7	0.48
2	3	2.60	0.75	2.7	0.48	2.5	0.97
3	2	1.50	0.82	1.4	0.84	1.6	0.84
4	1	0.80	0.41	0.7	0.48	0.9	0.32
5	2	1.75	0.55	1.7	0.48	1.8	0.63
6	2	0.15	0.37	0.2	0.20	0.1	0.32
7	1	0.55	0.51	0.7	0.48	0.4	0.52
8	1	0.45	0.51	0.5	0.53	0.4	0.52
9	1	0.30	0.47	0.3	0.48	0.3	0.48
10	1	0.85	0.37	0.9	0.32	0.8	0.42
B. 1	1	0.95	0.22	1.0	0.00	0.9	0.32
2	3	2.95	0.22	3.0	0.00	2.9	0.32
3	2	1.90	0.44	2.0	0.00	1.8	0.63
4	1	0.85	0.37	0.8	0.42	0.9	0.32
5	2	1.85	0.37	1.8	0.42	1.9	0.32
6	2	0.70	0.47	0.6	0.52	0.8	0.42
7	1	0.75	0.44	0.8	0.42	0.7	0.48
8	1	0.65	0.49	0.8	0.42	0.5	0.53
9	1	0.80	0.41	0.8	0.42	0.8	0.42
10	1	0.95	0.22	0.9	0.32	1.0	0.00

Table 21 CHILDREN'S UNDERSTANDING OF THE POSITIONING OF MAP LETTERING - ITEM DIFFICULTY

QUESTION	GROUP	YEAR 5	YEAR 8
A. 1	0.60	0.5	0.7
2	0.70	0.7	0.7
3	0.70	0.6	0.8
4	0.80	0.7	0.9
5	0.80	0.7	0.9
6	0.15	0.2	0.1
7	0.55	0.7	0.4
8	0.45	0.5	0.4
9	0.30	0.3	0.3
10	0.85	0.9	0.8
B. 1	0.95	1.0	0.9
2	0.95	1.0	0.9
3	0.95	1.0	0.9
4	0.85	0.8	0.9
5	0.85	0.8	0.9
6	0.70	0.6	0.8
7	0.75	0.8	0.7
8	0.65	0.8	0.5
9	0.80	0.8	0.8
10	0.95	0.9	1.0

Table 22 CHILDREN'S UNDERSTANDING OF THE CONCEPT OF MAP - ITEM ANALYSIS

QUESTION	MARKS	X_{GROUP}	SD_{GROUP}	X_5	SD_5	X_8	SD_8
1	2	1.15	0.37	1.1	0.32	1.2	0.42
2	4	2.65	0.81	2.3	0.95	3.0	0.47
3	4	2.20	1.00	1.6	0.84	2.8	0.78

Table [illegible] CHILDREN'S UNDERSTANDING OF THE CONCEPT OF MAP - ITEM DIFFICULTY

QUESTION	GROUP	YEAR 5	YEAR 8
1	0.15	0.1	0.2
2	0.10	0.1	0.1
3	0.10	0.0	0.2

The children also undertook three subjective tasks devised by the investigator to determine their attitudes to maps, their home environment and their previous experiences with maps. The children found no difficulty with the range of map extracts in the measurement of their attitudes to maps (Appendix 10). They appreciated the use of a practice example to illustrate the semantic differential technique. Several of the younger children sought clarification of terms such as "predictable", "clustered", "monotonous information" and "highly contrasted". These terms were explained orally and the children completed the tasks without difficulty. Therefore, the measure of children's attitudes to maps remained unchanged.

The surveys of the children's home environment (Appendix 12) and their previous experiences with maps

(Appendix 11) were received without difficulty. The children did not think that any of the questions invaded their privacy, especially since the information was treated confidentially and anonymously. The younger children preferred written answers which allowed them to verbalise, e.g. on the question of parental occupation (Home Environment Survey) they described the occupation without actually naming it. Consequently, both surveys were not changed for the final study.

Summary. The pilot study served as a guide to the children's understanding of and approach to a range of investigator - designed instruments. The item analyses and analyses of item difficulty indicated that: (a) the competence-in-cartographic language tests were effective and discriminating; (b) the tests on the map design variables - colour, map generalisation and map lettering - were effective, except for several questions in the map generalisation test which were discarded because they proved too difficult for the children and were not discriminating; and (c) the children's understanding of the concept of a map was incomplete, but it revealed some understanding. The children did not report difficulty with the verbal language used in the questions, except for several terms used in the attitudes-to-maps' measure (These were overcome by the supervisor's oral explanation).

3.40 Administrative and data-gathering procedures.

The data for this study were collected over a five week period in July and August, 1978. It consisted of administering fourteen instruments to the children in the study group. The instruments consisted of:

(a) the Salomon-Feldman map-reasoning test as the criterion reference,

(b) the competence-in-cartographic language test,

(c) the free-recall sketch map of the school to analyse the children's performance in cartographic language,

(d) three map design variables - colour, generalisation and lettering - which measured children's understanding of these map design aspects, and

(e) nine map user variables : map-reading ability, home environment, previous experience with maps, understanding of the concept of a map, drawing ability, attitudes to maps, non verbal intelligence, verbal intelligence and spatial ability , which measured attributes the map user brought to the cartographic communication situation.

Each instrument was administered to class groups which ranged in size from 26 to 38 children. The times the children spent on each task were mentioned earlier. Numbers of staff members in each school were trained as test administrators. All were volunteers. During the training sessions, each supervisor became familiar with each instrument, the method of its administration and possible difficulties the children may encounter (as they emerged in the pilot study). The supervisors were provided with a schedule for administering the tests, lists of key instructions for each instrument (including the duration of each task) and the location of the next use of that particular instrument. The investigator (or his designated supervisor) co-ordinated the daily administration of the instruments.

The investigator usually possessed a class set of base maps or test booklets for individual instruments.

Therefore, he devised an elaborate user schedule for each school so that the instruments were presented in a random order and they were spaced to minimise any cumulative effects from continuous exposure to maps. Wherever possible, the children did not undertake more than two instruments involving maps in any day. During the intervening periods, the children relaxed at physical education, music and cultural activities.

Each instrument was prefaced by a set of general instructions which indicated its purpose and the desirability for children to clarify any ambiguities they experienced with the questions. Specific instructions were included with individual questions to direct the children's responses.

The instructions detailed in the administrator's manuals were the ones used for administering the standardised tests. Supervisors did not report any difficulty administering these tests.

The children were provided with the necessary scoring sheets and resources for each instrument. Spare rulers and pencils were available should the children require them.

The data were scored by several methods. Specialists were used to score the children's performance in cartographic language and their drawing ability. Two specialists in geographical education who had been briefed in the scoring method devised by Snyder, Feldman and La Rossa (1975), scored the children's free-recall sketch maps. Specialists in art education used the Eisner scale to rate the children's maps. The standardised tests on children's map-reading ability, verbal intelligence, nonverbal intelligence and spatial ability, were scored and scaled according to the relevant manuals. The investigator-designed instruments were scored according to the accuracy of the children's responses. Answers to the investigator-designed instruments are presented in Appendices 15 to 20. The standardised tests and the investigator-designed instruments were scored by the investigator.

3.50 Experimental design of the study.

Three separate designs were used in this study since there are two different sets of independent variables and different combinations of dependent variables. The first situation consists of one independent variable (map-reasoning level) against which is matched one dependent variable (either competence or performance in cartographic language). The second situation consists of one independent variable (map-reasoning level) against which is matched thirteen dependent variables : colour in cartographic signs (V_1), map generalisation (V_2), map lettering (V_3), age (V_4), map-reading ability (V_5), home environment (V_6), previous experience with maps (V_7), understanding the concept of a map (V_8), drawing ability (V_9), attitudes to maps (V_{10}), nonverbal intelligence (V_{11}), verbal intelligence (V_{12}) and spatial ability (V_{13}). The third situation consists of a combination of independent variables (either map-reasoning level and competence in cartographic language or map-reasoning level and performance in cartographic language). The combination of map-reasoning level and competence in cartographic language had matched against it each of the above thirteen variables. The combination of map-reasoning level and performance in cartographic language had matched against it each of the above thirteen variables and the children's competence in cartographic language (V_{14}). The three designs are:(a) a univariate design, (b) a multivariate design, and (c) a multiple regression design.

3.51 Univariate design.

The univariate design consists of a randomised block design in which the independent variable(map-reasoning level) is organised into four blocks (low, medium, high and very high) with 75 children in each block. The dependent variables - competence in cartographic language and performance in cartographic language - are matched against the map reasoning levels of the four blocks of children (Table 24).

A randomised block design was used instead of a completely randomised design or a factorial design because it has the advantage of minimising the effects of individual differences by isolating that part of the total variance that is due to the blocks. Therefore, the error term for testing the treatment mean square is free of the nuisance variable that might be attributed to individual differences (Kirk, 1968: 147-148). Kirk (1968: 131) states that homogeneity within a block can be achieved by the use of : (a) identical twins, (b) tests to match subjects, or (c) a subject as his own control. The method that was used to establish homogeneity in this study was to use the subject as his own control. This method is appropriate if it is assumed that a subject is the same for each treatment level as he was at previous administrations of the treatment.

Table 24 SCHEMATIC MODEL OF THE 4 X 1 RANDOMISED BLOCK DESIGN

MAP-REASONING LEVEL	SUBJECTS	COMPETENCE IN CART. LANGUAGE (V_1)	PERFORMANCE IN CART. LANGUAGE (V_2)
B_1	S_1	$X_{1.1}$	$X_{1.2}$
	.	.	.
	.	.	.
	S_{75}	$X_{75.1}$	$X_{75.2}$
B_2	S_{76}	$X_{76.1}$	$X_{76.2}$
	.	.	.
	.	.	.
	S_{150}	$X_{150.1}$	$X_{150.2}$
B_3	S_{151}	$X_{151.1}$	$X_{151.2}$
	.	.	.
	.	.	.
	S_{225}	$X_{225.1}$	$X_{225.2}$
B_4	S_{226}	$X_{226.1}$	$X_{226.2}$
	.	.	.
	.	.	.
	S_{300}	$X_{300.1}$	$X_{300.2}$

B_1 = Low Group
B_2 = Medium Group
B_3 = High Group
B_4 = Very High Group
S_1 = Subject No. 1
S_{300} = Subject No. 300

The following fixed effects linear model is appropriate when using a randomised block design:

$$X_{ij} = \mu + \beta_j + \pi_i + \varepsilon_{ij}$$

where

X_{ij} = the score of a subject in cell ij.

μ = the grand mean of treatment populations which is constant for all observations.

β_j = the effect of treatment j, which is constant for all observations within treatment population j.

π_i = a constant associated with block i.

ε_{ij} = experimental error, which is independent of other ε's and normally distributed with each treatment population and with mean =0 and variance $=\sigma_{\varepsilon}^2$.

For this study, β_j represents the effect of being in the j th competence/performance treatment group; π_i is the constant associated with block i (the i th individual); and ε_{ij} represents the within cell experimental error which, according to the model, has a normal distribution (Kirk, 1968: 135-136). The analysis of variance summary table corresponding to this model is shown in Table 25.

Table 25 ANALYSIS OF VARIANCE SUMMARY TABLE FOR A RANDOMISED BLOCK DESIGN

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES
Between Blocks (B)	k - 1	SS_B
Within Blocks (W)	k(n - 1)	SS_W
TOTAL (T)	kn - 1	SS_T

This design was used to test the effect of the children's competence and performance in cartographic language on their map-reasoning level. It was used to test the null hypotheses associated with questions 1 and 2 presented in Chapter 1.

The appropriate statistic for testing the null hypotheses in this design is the F test. For the randomised block design, the null hypotheses are tested using:

$$F = \frac{SS_B / (k - 1)}{SS_R / (k - 1) . (n - 1)}$$

The F test, as it is applied to the randomised block design, assumes that the variance - covariance matrix is homogeneous. Since the independent variable in this study is a fixed effect, the error term for the hypotheses to be tested is the pooled within-group variance - covariance matrix divided by its degrees of freedom.

A multiple comparisons analysis was conducted where the above comparisons reveal a significant F. Tukey's HSD (honestly significantly different) test was used for this purpose because pairwise comparisons are important and the number of subjects in each treatment group is the same (N=75). Significant differences between pairwise means were tested using the formula

$$HSD = q \alpha \gamma \sqrt{\frac{MS_{WG}}{n}}$$

where q is obtained from a table of the studentised range statistic for $V = n - k$ degrees of freedom,

n = the sample number, and

MS_{WG} = the within group mean square.

This statistical exercise was computed using the ONEWAY sub-program of SPSS.

3.52 Multivariate design.

The basic multivariate design consists of a randomised block design in which the independent variable (map-reasoning level) is organised into four blocks (low, medium, high and very high) with 75 children in each block. The dependent variables - three map design variables (V_1 to V_3) and ten map user variables (V_4 to V_{13}) - were matched against the map-reasoning levels of the four blocks of children (Table 26).

The rationale for using a multivariate analysis of variance in this study may be described as follows. The four blocks of an independent variable (map-reasoning level) were compared in terms of the thirteen dependent variables - three map design variables (V_1 to V_3) and ten map user variables (V_4 to V_{13}). This necessitated the use of a statistical technique which examined differences among the blocks on the thirteen dependent variables simultaneously as well as separately. Multivariate analysis, in combination with discriminant analysis, contains both of these features, whereas a range of univariate analyses only allows comparisons to be made separately with respect to dependent variables (Jones, 1966: 245; Tatsuoka, 1971: 62). Further, Cramer and Bock (1966: 605) stress that it appropriate for a researcher to consider separate univariate analyses of the dependent variables following a significant multivariate statistic. In this study, the procedure of Cramer and Bock was followed.

Jones (1966; 246) and Tatsuoka (1971: 196) note that

1 = Low Group; 2 = Medium Group; 3 = High Group; 4 = Very High Group.

V_1= Colour in Cartographic Signs Score; V_2 = Map Generalisation Score; V_3 = Map Lettering Score;V_4 = Age;V_5 = Map-Reading Ability Score; V_6 = Home Environment Score;V_7 = Previous Experience with Maps Score; V_8 = Map Concept Score;V_9 = Drawing Ability Score;V_{10} = Attitudes to Maps Score;V_{11} = Non Verbal Intelligence Score;V_{12} = Verbal Intelligence; V_{13} = Spatial Ability Score.

Table 26 SCHEMATIC MODEL OF THE 4 X 13 RANDOMISED MULTIVARIATE DESIGN

MAP-REASONING BLOCKS	SUBJECTS	MAP DESIGN VARIABLES			MAP USER VARIABLES								
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	....	V_{11}	V_{12}	V_{13}
1	S_1	$\underline{X}_{1.1}$	$\underline{X}_{1.2}$	$\underline{X}_{1.3}$	$\underline{X}_{1.4}$	$\underline{X}_{1.5}$	$\underline{X}_{1.6}$	$\underline{X}_{1.7}$	$\underline{X}_{1.8}$	....	$\underline{X}_{1.11}$	$\underline{X}_{1.12}$	$\underline{X}_{1.13}$
	.	.	.	.	.	.	.	.	.		.	.	.
	S_{75}	$\underline{X}_{75.1}$	$\underline{X}_{75.2}$	$\underline{X}_{75.3}$	$\underline{X}_{75.4}$	$\underline{X}_{75.5}$	$\underline{X}_{75.6}$	$\underline{X}_{75.7}$	$\underline{X}_{75.8}$	....	$\underline{X}_{75.11}$	$\underline{X}_{75.12}$	$\underline{X}_{75.13}$
2	S_{76}	$\underline{X}_{76.1}$	$\underline{X}_{76.2}$	$\underline{X}_{76.3}$	$\underline{X}_{76.4}$	$\underline{X}_{76.5}$	$\underline{X}_{76.6}$	$\underline{X}_{76.7}$	$\underline{X}_{76.8}$	....	$\underline{X}_{76.11}$	$\underline{X}_{76.12}$	$\underline{X}_{76.13}$
	.	.	.	.	.	.	.	.	.		.	.	.
	S_{150}	$\underline{X}_{150.1}$	$\underline{X}_{150.2}$	$\underline{X}_{150.3}$	$\underline{X}_{150.4}$	$\underline{X}_{150.5}$	$\underline{X}_{150.6}$	$\underline{X}_{150.7}$	$\underline{X}_{150.8}$	....	$\underline{X}_{150.11}$	$\underline{X}_{150.12}$	$\underline{X}_{150.13}$
3	S_{151}	$\underline{X}_{151.1}$	$\underline{X}_{151.2}$	$\underline{X}_{151.3}$	$\underline{X}_{151.4}$	$\underline{X}_{151.5}$	$\underline{X}_{151.6}$	$\underline{X}_{151.7}$	$\underline{X}_{151.8}$	....	$\underline{X}_{151.11}$	$\underline{X}_{151.12}$	$\underline{X}_{151.13}$
	.	.	.	.	.	.	.	.	.		.	.	.
	S_{225}	$\underline{X}_{225.1}$	$\underline{X}_{225.2}$	$\underline{X}_{225.3}$	$\underline{X}_{225.4}$	$\underline{X}_{225.5}$	$\underline{X}_{225.6}$	$\underline{X}_{225.7}$	$\underline{X}_{225.8}$	....	$\underline{X}_{225.11}$	$\underline{X}_{225.12}$	$\underline{X}_{225.13}$
4	S_{226}	$\underline{X}_{226.1}$	$\underline{X}_{226.2}$	$\underline{X}_{226.3}$	$\underline{X}_{226.4}$	$\underline{X}_{226.5}$	$\underline{X}_{226.6}$	$\underline{X}_{226.7}$	$\underline{X}_{226.8}$	....	$\underline{X}_{226.11}$	$\underline{X}_{226.12}$	$\underline{X}_{226.13}$
	.	.	.	.	.	.	.	.	.		.	.	.
	S_{300}	$\underline{X}_{300.1}$	$\underline{X}_{300.2}$	$\underline{X}_{300.3}$	$\underline{X}_{300.4}$	$\underline{X}_{300.5}$	$\underline{X}_{300.6}$	$\underline{X}_{300.7}$	$\underline{X}_{300.8}$	....	$\underline{X}_{300.11}$	$\underline{X}_{300.12}$	$\underline{X}_{300.13}$

for a design with an equal number of observations in each cell, the model, the computations, and the decomposition of the total sum of squares and cross-products of a multivariate design are directly analogous to the model, computations, and the decompositions of the total sum of squares in the corresponding univariate analysis of variance. Therefore, the following fixed effects linear model is appropriate:

$$\underline{X}_{ij} = \mu + \beta_j + \pi_i + \varepsilon_{ij}$$

where $\underline{X}_{ij}$ = the score of a subject in cell ij.

μ = the grand mean of treatment populations which is constant for all observations.

β_j = the effect of treatment j, which is constant for all observations within treatment population j.

π_i = a constant associated with block i.

ε_{ij} = the within cell experimental error, which is independent of other ε's and normally distributed with each treatment population and with a mean = 0 and variance = σ_{ε}^2 .

(Kirk, 1968 : 135 -136)

The multivariate analysis of variance summary table corresponding to this model is shown in Table 26.

Table 27 ANALYSIS OF MULTIVARIANCE SUMMARY TABLE FOR A RANDOMISED BLOCK DESIGN

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	CROSS PRODUCT MATRICES
Constant	1	$\underline{S}_{H}$ 1	M_{H} 2
A. Eliminating Constant	1	$\underline{S}_{H}$ 2	M_{H} 2
Between Groups (B)	k - 1	$\underline{SS}_{B}$	M_{B}
Within Groups (W)	k(n - 1)	$\underline{SS}_{W}$	M_{W}
TOTAL (T)	kn + 1	$\underline{SS}_{T}$	

This design was used to test the effect of three map design variables (V_1 to V_3) and ten map user variables (V_4 to V_{13}) on children's map reasoning level. It was used to test the null hypothesis associated with question 3 presented in Chapter 1.

The appropriate statistic for testing the null hypothesis in this design is the F test. For the randomised block design, the null hypothesis was tested using:

$$F = \frac{M_{H\,2}}{M_W} \quad \text{or} \quad \frac{\underline{S}_{H\,2}/1}{\underline{SS}_W/k\,(n-1)}$$

The F test, as it was applied to the randomised block design, is based on the assumption that the variance - covariance matrix is homogeneous. Since the independent variable in this study is a fixed effect, the error term for the hypothesis to be tested is the pooled within-group variance - covariance matrix divided by its degrees of freedom.

When the factor of map-reasoning level was found to be significant using the multivariate procedure, a discriminant analysis was performed to determine the source of the difference in terms of the thirteen dependent variables. The source of difference was determined by constructing that linear function of the criterion variable - map-reasoning level - which maximally discriminates between the levels of the significant factor in a least squares sense, e.g.

$$V_{\text{map-reasoning}} = a_1V_1 + a_2V_2 + a_3V_3 + \ldots\ldots + a_{13}V_{13}$$

where $V_1, V_2, \ldots\ldots\ldots\ldots, V_{12}$ and V_{13} represent standardised scores on the dependent variables and a_1, a_2, ... a_{12} and a_{13} are coefficients written in standard form. The size and sign of the coefficients determined the relative influence of each dependent variable on the children's map-reasoning level.

Separate univariate analyses were also performed for each significant dependent variable, as suggested by Cramer and Bock (1966 : 605). The univariate analysis was the same as that explained in Chapter 3.51.

A multiple comparisons analysis was conducted where the above univariate comparisons revealed a significant F ratio. Tukey's HSD test, as detailed in Chapter 3.51, was used for this purpose.

The multivariate and discriminant analyses were computed using the NYBMUL program. The univariate analyses were computed using the ONEWAY subprogram of SPSS.

3.53 Multiple regression design.

Multiple regression analysis is the means for enabling observation and interpretation of the effects and the magnitudes of the effects of more than one independent variable on one dependent variable via the principles of correlation and regression (Kerlinger, 1973 : 603). The basic prediction equation is:

$$Y' = a + b_1 X_1 + \dots\dots\dots + b_k X_k$$

where Y' = the predicted score of the dependent variable,

a = the intercept constant,

$b_1 \dots b_k$ = the regression coefficients for 1 to k independent variables, and

$X_1 \dots . X_k$ = independent variables.

An index of the magnitude of the relation between a least-squares composite of X_1 and X_2, and Y, is the multiple correlation coefficient R. It is calculated from the ordinary product-moment coefficient of correlation (r) between the predicted values (Y') and the observed values of Y:

$$R = \frac{\Sigma y . y'}{\sqrt{\Sigma y^2 . \Sigma y'^2}}$$

R, unlike r, does not have negative values. It varies from 0 to 1.00.

The statistical significance of the multiple regression coefficient is obtained using the F ratio which is calculated using the formula:

$$F = \frac{R^2 / k}{(1 - R^2) / (N - k - 1)}$$

where R = the multiple correlation coefficient,

k = the number of independent variables and

N = the sample size. (Kerlinger, 1973 : 620)

Two series of multiple regression analyses were performed in this study. In the first series, the scores of three map design variables (V_1 to V_3) and ten map user variables (V_4 to V_{13}) were predicted from a combination of two independent variables (map-reasoning level and competence in cartographic language) using the formula

$$Y'_{V_1} = a + b_1 X_1 + b_2 X_2$$

where Y'_{V_1} = the predicted score on V_1 (colour in cartographic signs),

a = the intercept constant,

X_1 = the child's map-reasoning score,

b = the regression coefficient for map-reasoning level,

X_2 = the child's competence-in-cartographic language score, and

b_2 = the regression coefficient for competence in cartographic language.

In the second series of multiple regression analyses, the scores of three map design variables (V_1 to V_3) and eleven map user variables (V_4 to V_{13} and the children's competence in cartographic language) were predicted from a combination of independent variables (map-reasoning level and performance in cartographic language), using the formula

$$Y'_{V_1} = a + b_1 X_1 + b_2 X_2$$

where Y'_{V_1} = the predicted score on V_1 (colour in cartographic signs),

a = the intercept constant,

X_1 = the child's map-reasoning level score,

b_1 = the regression coefficient for map-reasoning level,

x_2 = the child's performance-in-cartographic language score, and

b_2 = the regression coefficient for performance in cartographic language.

The above two series of multiple regression analyses indicated which dependent variables influence children's map-reasoning, and competence or performance in cartographic language. The multiple regression analyses were computed using the NYBMUL program. This design was used to test the null hypotheses associated with questions 4, 5, 6 and 7 presented in Chapter 1.

3.54 Subjective analyses.

Simple statistical procedures, e.g. frequency counts, and the children's subjective comments, were used to reinforce and/or complement the above statistical analyses. More specifically, these analyses are concerned with the children's perceptions of the map concept, map lettering and the use of colour in cartographic signs.

The analysis of the children's definitions of a map was used to determine whether there is any progression in their definitions. It consists of classifying their definitions into four categories - a picture, a reference, a location or a representation. The frequency of the children's responses were calculated and are presented as percentages.

The analysis of the children's responses to the map lettering test was to ascertain their perceptions of the use of typography on maps and to establish whether there is any development in their perceptions. The frequency of the children's responses were counted for each block.

The analysis of the children's perception of colour in cartographic signs was to ascertain their preference for colour and to establish if there was any development in their preferences across the four map-reasoning blocks. The children's responses are organised on the frequency of their occurrence and are presented as percentages.

3.60 Reliability of the test instruments.

Test reliability is the degree to which errors of measurement influence test scores. Womer (1968 : 34-37) indicates that it may be computed in one of three ways: (a) test-retest reliability, (b) the split half method, and (c) the Kuder-Richardson method. The test reliability for most of the standardised tests in this study was computed by either the split-half method or the test-retest method. The investigator-designed instruments used the Kuder - Richardson method of test reliability.

The reliability studies in this investigation are presented in two sections: (a) those related to the standardised test instruments and (b) those related to the investigator-designed instruments.

3.61 Reliability studies of standardised tests.

The standardised instruments used in this study are: (a) Jenkins Nonverbal Test , (b) A.C.E.R. Intermediate Test, (c)Iowa Tests of Basic Skills (Test W-1), (d) A.C.E.R. Space Test, (e) Salomon-Feldman Map-reasoning Test, (f) Eisner's Drawing Ability Test, and (g) Snyder, Feldman and La Rossa's Test of Map Drawing Ability. The split-half method was used for the A.C.E.R. Intermediate Test A, Jenkins Non verbal Test and the Iowa Tests of Basic Skills

(Test W-1). The test-retest method was used for the Salomon-Feldman Map Reasoning Test. Eisner's Drawing Ability Test and Snyder, Feldman and La Rossa's Test of Map-Drawing Ability were tested on the basis of inter-rater reliability. The A.C.E.R. Space Test was tested on the basis of the "best fit" of questions using the Rasch model.

The split-half method uses the Spearman Brown formula which corrects for the length of the test:

$$R = \frac{2r}{1 + r}$$

where R = the reliability coefficient of the test as a whole and

r = the coefficient obtained by correlating the two halves.

The Australian Council for Educational Research (1964: 17) reported a reliability coefficient of 0.95 for Intermediate Test A. A.C.E.R. reported split-half reliability coefficients of 0.96 for a random sample of 11.6 year old children and 0.94 for a random sample of 12.6 year old children for the Jenkins Nonverbal Test (A.C.E.R., 1973; 26). Hieronymus and Lindquist (1974: 57-59) reported the reliability coefficients for the Iowa Tests of Basic Skills: Forms 5 and 6. Those for Test W-1 are presented in Table 28.

Table 28 IOWA TESTS OF BASIC SKILLS - TEST W-1

RELIABILITY COEFFICIENTS

LEVEL	RELIABILITY COEFFICIENTS
9	.75
10	.82
11	.83
12	.79
13	.82
14	.85

Salomon and Feldman (1969) tested the reliability of their map-reasoning test using the test-retest method. They reported a test-retest reliability coefficient of 0.81 using a sample of 48 St.Paul children (Feldman and Markwalder, 1971: 352).

Inter-rater reliability was used as the basis for analysing the reliability of Snyder, Feldman and La Rossa's map-drawing ability test and Eisner's ability test. Wilson (1979) used the same two expert raters for the same map-drawing test. He used Snedecor's formula for inter-rater reliability:

$$r_1 = \frac{M_{\bar{x}} - M}{M_{\bar{x}} + (k - 1)\,M}$$

where M = the mean square for error,

$M_{\bar{x}}$ = the mean square for the subject's estimated scores, and

k = the number of estimates of a particular score (Mehrens and Ebel, 1967: 118-119).

Wilson used a random sample of 49 children in similar age groups to the ones used in this study. He reported an inter-rater reliability of 0.89. Therefore, the investigator assumed that the same expert raters would bring a similar reliability to their scoring of the free-recall sketch maps in this study.

Eisner (1967: 49-50) established the inter-rater reliability of his drawing test via a protracted series of training sessions. He concluded that the correlation coefficients between the two judges was 0.81; between judge 1 and the joint judgment was 0.91; and for judge 2 it was 0.87. Therefore, the investigator concluded that Eisner's drawing test was reliable.

The A.C.E.R. Space Test was the only standardised test used in this study which did not possess conventional reliability analysis. This is because the test is based on the Rasch measurement approach (1966) which relies on the "best fit" of items as the basis for their inclusion in a test. This reaction against conventional reliability is typified by Lumsden (1976:266) who maintains that the whole conception of psychological testing depends on the notion of unidimensionality and therefore the Rasch model is an appropriate model. The Rasch model indicates that once a pool of fitting items relating to some unidimensional trait has been established, any sub-set of items in the pool can be used to measure the ability of a person with respect to that trait. Test items for the A.C.E.R. Space Test were selected according to the Rasch probability of item fit.

3.62 Reliability studies of investigator-designed instruments.

All of the investigator-designed tests are single administrations of particular instruments. One of the two Kuder-Richardson formulas is a common method for estimating reliability from a single test administration. These formulas measure the homogeneity of the items of a test. They do not assess stability over time (Womer, 1968:37). Anastasi (1968; 85) states that the Kuder-Richardson formula 20 is the most widely applicable formula for computing reliability coefficients. The reliability coefficient r is obtained using the following formula:

$$r = \left(\frac{n}{n-1}\right)\cdot\left(\frac{SD^2 - \mathcal{E}pq}{SD^2}\right)$$

where n = the number of test items,

SD = the standard deviation of the test,

p = the percentage of children passing the item,

q = the percentage of children failing the item, and

$\mathcal{E}pq$ = the summation of the product of p and q for each item.

The adequacy of the r value depends on the purpose of the test. Irons (1975: 113) states that most investigators report that 0.80 is a satisfactory reliability coefficient. Womer (1968; 41) indicates that lower measures are acceptable. when group work is being considered. He also states that the length of the test is vital when assessing its reliability. Tests of twenty items may not be adequate to obtain any accurate measure (Womer, 1968: 42). The number of items in particular tests in this study ranged from ten to 110. The coefficients for the shorter instruments are, therefore, not expected to be large.

The reliability coefficients for the investigator-designed instruments are presented in Table 29. The number of items in each test is also reported. It is not surprising that most of the smaller tests produced smaller reliability coefficients. The only coefficient that is considered small is the one for the survey of children's previous experiences with maps (0.38). This coefficient may be small because the children were asked to report experiences rather than to answer a test. The map concept test reliability coefficient is small because of the small number of test items. All other reliability coefficients were considered adequate.

Table 29 RELIABILITY COEFFICIENTS FOR INVESTIGATOR-DESIGNED INSTRUMENTS (K-20 METHOD)

INSTRUMENT	RELIABILITY COEFFICIENT	NUMBER OF ITEMS
COMPETENCE IN CART. LANGUAGE	.94	110
COLOUR IN CART. SIGNS	.81	10
MAP GENERALISATION	.91	30
MAP LETTERING	.75	20
MAP CONCEPT	.69	10
ATTITUDES TO MAPS	.75	20
HOME ENVIRONMENT SURVEY	.78	30
PREVIOUS MAP EXPERIENCE SURVEY	.38	21

CHAPTER FOUR PRESENTATION AND ANALYSIS OF DATA

The analysis of data in this study indicates how children at the concrete level of map-reasoning develop competence and performance in cartographic language. It also indicates which map design and map user variables influence children's map-reasoning, and competence and performance in cartographic language.

The analysis of data is presented in four parts. Part one deals with the hypotheses related to children's competence and performance in cartographic language. It focuses on testing the null hypotheses associated with questions 1 and 2 in Chapter 1. Part two deals with the hypothesis related to the children's performance scores on three map design variables (V_1 to V_3) and ten map user variables (V_4 to V_{13}). It focuses on testing the null hypothesis associated with question 3 in Chapter 1. Part three deals with the hypotheses related to predicted performance scores on three map design variables (V_1 to V_3) and on eleven map user variables (V_4 to V_{14}). It focuses on testing the null hypotheses associated with questions 4, 5, 6 and 7 in Chapter 1. Part four deals with the presentation of data in the form of simple statistical procedures, e.g. frequency counts, and subjective comments by the children. It provides information to answer question 8 in Chapter 1.

The hypotheses have been separated into three parts because three different experimental designs were used to analyse the variables (see Chapter 3.5). A univariate randomised block design was used to analyse the children's competence and performance in cartographic language. A multivariate randomised block design was used to analyse the influence of three map-design variables (V_1 to V_3) and ten map user variables (V_4 to V_{13}) on the children's map-reasoning. A multiple regression design was used to analyse: (a) the predicted scores of three map design variables (V_1 to V_3) and ten map user variables (V_4 to V_{13}) in relation to the combination of the children's map-reasoning level and their competence in cartographic language, and (b) the predicted scores of three map design variables (V_1 to V_3) and eleven map user variables (V_4 to V_{14}) in relation to the combination of the children's map-reasoning level and their performance in cartographic language.

Selected subjective observations by the children in the study group and frequency counts have been included in this chapter to amplify the children's performance in cartographic language, their definition of a map, their perceptions of colour in cartographic signs and their understanding of the positioning of names on a map.

4.1 Testing of hypotheses associated with the univariate design.

The hypotheses considered in this part are presented below in null form for reference purposes:

1. There is no difference between the mean performances of subjects in four map-reasoning levels for their competence in cartographic language.
2. There is no difference between the mean performances of subjects in four map-reasoning levels for their performance in cartographic language.

The results of the reliability studies for the instruments measuring children's competence and performance in cartographic language were presented in

Chapter 3. Reliabilities for both instruments are high. Therefore, the reliability data lend support to the interpretation of results contained in this section.

The analyses of data for this part of the study were performed using the SPSS sub-program ONEWAY which computed a univariate analysis of variance followed by a Tukey HSD test for the purpose of multiple classification analysis.

Hypothesis 1. There is no difference between the mean performances of subjects in four map-reasoning levels for their competence in cartographic language.

The children's scores on their competence in cartographic language are subdivided into:(a) scores of identification and comprehension on standard elements (V_1 to V_2), qualitative line signs (V_3 and V_4), quantitative line signs (V_5 and V_6), qualitative point signs (V_7 and V_8), quantitative point signs (V_9 and V_{10}), qualitative area signs (V_{11} and V_{12}) and quantitative area signs (V_{13} and V_{14}); (b) sub-total scores on the identification of qualitative signs (V_{15}), the comprehension of qualitative signs (V_{16}), the identification of quantitative signs (V_{17}), the comprehension of quantitative signs (V_{18}), the identification of all signs (V_{19}) and the comprehension of all signs (V_{20}); and (c) the total score of children's competence in cartographic language (V_{21}). The mean scores and standard deviations for these variables are presented in Tables 30 and 31 respectively.

Block 1 = Low Group; Block 2 = Medium Group; Block 3 = High Group; Block 4 = Very High Group.

V_1= Identification of Standard Elements; V_2= Comprehension of Standard Elements; V_3= Identif. of Qual. Line Signs; V_4= Comp. of Qual. Line Signs; V_5= Identif. of Quant. Line Signs; V_6= Comp. of Quant. Line Signs; V_7= Identif. of Qual. Point Signs; V_8= Comp. of Qual. Point Signs; V_9= Identif. of Quant. Point Signs; V_{10}= Comp. of Quant. Point Signs; V_{11}= Identif. of Qual. Area Signs; V_{12}= Comp. of Qual. Area Signs; V_{13}= Identif. of Quant. Area Signs; V_{14}= Comp. of Quant. Area Signs; V_{15}= Total Identif. of Qual. Signs; V_{16}= Total Comp. of Qual. Signs; V_{17}= Total Identif. of Quant. Signs; V_{18}= Total Comp. of Quant. Signs; V_{19}= Total Identif. of Signs; V_{20}= Total Comp. of Signs; V_{21}= Grand Total Score.

Table 30 MEANS OF CHILDREN'S SCORES ON THEIR COMPETENCE IN CARTOGRAPHIC LANGUAGE BY MAP-REASONING BLOCKS

BLOCKS	RAW SCORE MEANS											
	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}
1	2.84	9.88	5.95	10.94	1.42	5.36	5.20	10.81	2.19	6.40	2.84	9.88
2	3.36	12.98	6.93	11.92	1.70	6.49	5.69	12.58	2.35	8.37	3.36	12.98
3	4.26	17.53	7.22	15.41	2.36	8.85	7.08	16.83	3.04	10.89	4.27	17.53
4	5.60	21.24	7.60	19.78	3.07	12.27	7.37	20.09	3.27	13.12	5.60	21.24

BLOCKS	RAW SCORE MEANS								
	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	V_{21}
1	5.95	10.95	1.41	5.36	5.20	10.81	2.19	6.40	2.89
2	6.93	11.92	1.70	6.49	5.69	12.59	2.34	8.37	3.95
3	7.23	15.41	2.36	8.85	7.08	16.83	3.04	10.89	5.20
4	7.60	19.78	3.07	12.27	7.37	20.09	3.27	13.12	6.59

V_1=Identif. of Standard Elements;V_2=Comprehension of Standard Elements;V_3= Identif. of Qual.Line Signs; V_4=Comp. of Qual. Line Signs;V_5=Identif. of Quant. Line Signs;V_6=Comp. of Quant. Line Signs;V_7= Identif. of Qual. Point Signs;V_8= Comp. of Qual. Point Signs;V_9= Identif. of Quant. Point Signs; V_{10}= Comp. of Quant. Point Signs;V_{11}= Identif. of Qual. Area Signs;V_{12}= Comp. of Qual. Area Signs; V_{13}= Identif. of Quant. Area Signs;V_{14}= Comp.of Quant. Area Signs;V_{15}= Total Identif. of Qual. Signs;V_{16}= Total Comp. of Qual. Signs;V_{17}= Total Identif. of Quant. Signs;V_{18}= Total Comp. of Quant. Signs;V_{19}= Total Identif. of Signs;V_{20}= Total Comp. of Signs;V_{21}= Grand Total Competence Score.

Table 30 indicates that, for all variables, the group means increase from block 1 through block 4. It also indicates that there is a gradual increase in the difference between the group means from block 1 through block 4 for V_1 (identification of standard elements), V_4 (comprehension of qualitative line signs), V_5 (identification of quantitative line signs), V_6 (comprehension of quantitative line signs), V_{11} (identification of qualitative area signs), V_{14} (comprehension of quantitative area signs), V_{15} (total identification of qualitative signs), V_{16} (total comprehension of qualitative signs) and V_{21} (grand total competence score). There are several variables for which the largest difference between group means is between blocks 2 and 3, followed by the difference between blocks 3 and 4. These are V_2 (comprehension of standard elements), V_3 (comprehension of qualitative point signs), V_9 (identification of quantitive point signs), V_{10} (comprehension of quantitative point signs), V_{12} (comprehension of qualitative area signs), V_{18} (total comprehension of quantitative signs), V_{19} (total identification of signs) and V_{20} (total comprehension of signs). Therefore, there is a general trend to larger group means and larger differences between each pair of group means from block 1 to block 4.

Table 32 presents the results of the univariate analysis of variance for hypothesis 1.

The univariate F tests in Table 32 indicate that there is a highly significant variation among the group means for all measured aspects of the children's competence in cartographic language when the children are blocked according to their map-reasoning level.

Table 32 UNIVARIATE ANALYSIS OF VARIANCE USING 21 VARIABLES OF COMPETENCE IN CARTOGRAPHIC LANGUAGE

VARIABLE	df	F	p
V_1	3	20.28	.0000**
V_2	3	45.33	.0000**
V_3	3	13.48	.0000**
V_4	3	37.64	.0000**
V_5	3	34.15	.0000**
V_6	3	62.64	.0000**
V_7	3	20.61	.0000**
V_8	3	43.74	.0000**
V_9	3	19.44	.0000**
V_{10}	3	52.76	.0000**
V_{11}	3	20.28	.0000**
V_{12}	3	45.33	.0000**
V_{13}	3	13.48	.0000**
V_{14}	3	37.64	.0000**
V_{15}	3	34.15	.0000**
V_{16}	3	62.64	.0000**
V_{17}	3	20.61	.0000**
V_{18}	3	43.74	.0000**
V_{19}	3	19.44	.0000**
V_{20}	3	52.76	.0000**
V_{21}	3	39.14	.0000**

** significant at 0.0001 level

This is so for their competence in the identification and comprehension of line , point and area cartographic signs and standard elements. The criterion reference - the Salomon-Feldman map-reasoning test - incorporates the

Piagetian concept of development. Consistent significant variance among the group means is essential if this developmental characteristic is evident in the children's competence in cartographic language. Since the differences reported in Table 32 are so highly significant, there is evidence of development in the children's competence across the four map-reasoning blocks.

All of the variables in Table 32 display high F ratios with p values less than 0.0001. The Tukey method of multiple comparisons was used to determine which groups are responsible for the significant F ratios on all variables. The Tukey method was chosen because all blocks were the same size and the investigator was interested only in the differences between pairs of the four map-reasoning blocks (Hopkins and Chadbourn, 1967: 407-412). In the Tukey method, a difference between the two means is significant if it exceeds the value HSD, where

$$HSD = q\alpha\gamma \sqrt{\frac{MS_{WG}}{n}}$$

as elaborated in Chapter 3.51. Since $q\alpha\gamma$ is the 100 (1 -α) percentile point in the "studentised" range distribution with the hypothesis level set at ,
and γ degrees of freedom for the error term, it is necessary to know the number of levels of the factor when using the studentised range distribution. There are four levels for the factor of map-reasoning.

There were six pairs of means to be compared among the four map-reasoning levels: $\bar{X}_4 - \bar{X}_1$, $\bar{X}_4 - \bar{X}_2$, $\bar{X}_4 - \bar{X}_3$, $\bar{X}_3 - \bar{X}_2$, $\bar{X}_3 - \bar{X}_1$, and $\bar{X}_2 - \bar{X}_1$, where $\bar{X}_i$ corresponds to the mean for map-reasoning block i. The mean differences among the four map reasoning blocks and the appropriate HSD values for each of the dependent variables are presented in Table 33.

Table 33 MULTIPLE COMPARISONS FOR THE SIGNIFICANT VARIABLES ON THE UNIVARIATE TESTS CONCERNING COMPETENCE IN CARTOGRAPHIC LANGUAGE

A. Mean differences for variable V_1 (identification of standard elements

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	.52	1.43*	2.76*
$\bar{X}_2$		-	.90	2.24*
$\bar{X}_3$			-	1.34*
$\bar{X}_4$				-

HSD (α = 0.05) = 0.97

B. Mean differences for variable V_2 (comprehension of standard elements)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	3.1*	7.65*	11.36*
$\bar{X}_2$		-	4.55*	8.25*
$\bar{X}_3$			-	3.71*
$\bar{X}_4$				-

HSD (α = 0.05) = 2.71

C. Mean differences for variable V_3 (identification of qualitative line signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	.98*	1.28*	1.65*
$\bar{X}_2$		-	.29	.67
$\bar{X}_3$			-	.38
$\bar{X}_4$				-

HSD (α = 0.05) =0.73

D. Mean differences for variable V_4 (comprehension of qualitative line signs

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	.98	4.47*	8.84*
$\bar{X}_2$		-	3.49*	7.87*
$\bar{X}_3$			-	4.37*
$\bar{X}_4$				-

HSD (α = 0.05) = 2.4

E. Mean differences for variable V_5 (identification of quantitative line signs

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	.28	.95*	1.65*
$\bar{X}_2$		-	.66*	1.35*
$\bar{X}_3$			-	.71*
$\bar{X}_4$				-

HSD (α = 0.05) = 0.52

F. Mean differences for variable V_6 (comprehension of quantitative line signs

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.13	3.49*	6.91*
$\bar{X}_2$		-	2.36*	5.77*
$\bar{X}_3$			-	3.42*
$\bar{X}_4$				-

HSD (α = 0.05) = 1.42

G. Mean differences for variable V_7 (identification of qualitative point signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.49	1.88*	2.17*
$\bar{X}_2$		-	1.39*	1.68*
$\bar{X}_3$			-	0.29
$\bar{X}_4$				-

HSD (α = 0.05) = 0.82

H. Mean differences for variable V_8 (comprehension of qualitative point signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.77	6.01*	9.28*
$\bar{X}_2$		-	4.25*	7.51*
$\bar{X}_3$			-	3.26*
$\bar{X}_4$				-

HSD (α = 0.05) = 2.31

I. Mean differences for variable V_9 (identification of quantitative point signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.16	0.85*	1.08*
$\bar{X}_2$		-	0.69*	0.92*
$\bar{X}_3$			-	0.23
$\bar{X}_4$				-
HSD (α = 0.05) = 0.37				

J. Mean differences for variable V_{10} (comprehension of quantitative point signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.97*	4.49*	6.72*
$\bar{X}_2$		-	2.52*	4.75*
$\bar{X}_3$			-	2.23*
$\bar{X}_4$				-
HSD (α = 0.05) = 1.46				

K. Mean differences for variable V_{11} (identification of qualitative area signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.52	1.43*	2.76*
$\bar{X}_2$		-	0.91	2.24*
$\bar{X}_3$			-	1.33*
$\bar{X}_4$				-
HSD (α = 0.05) = 0.97				

L. Mean differences for variable V_{12} (comprehension of qualitative area signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	3.1*	7.64*	11.36*
$\bar{X}_2$		-	4.55*	8.25*
$\bar{X}_3$			-	3.71*
$\bar{X}_4$				-

HSD (α = 0.05) = 2.71

M. Mean differences for variable V_{13} (identification of quantitative area signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.98*	1.28*	1.65*
$\bar{X}_2$		-	0.3	0.67
$\bar{X}_3$			-	0.57
$\bar{X}_4$				-

HSD (α = 0.05) = 0.73

N. Mean differences for variable V_{14} (comprehension of quantitative area signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.97	4.47*	8.84*
$\bar{X}_2$		-	3.49*	7.87*
$\bar{X}_3$			-	4.37*
$\bar{X}_4$				-

HSD (α = 0.05) = 2.4

O. Mean differences for variable V_{15} (total identification of qualitative signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.29	0.95*	1.65*
$\bar{X}_2$		-	0.66*	1.36*
$\bar{X}_3$			-	0.71*
$\bar{X}_4$				-

HSD (α = 0.05) = 0.52

P. Mean differences for variable V_{16} (total comprehension of qualitative signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.13	3.49*	6.91*
$\bar{X}_2$		-	2.36*	5.77*
$\bar{X}_3$			-	3.41*
$\bar{X}_4$				-

HSD (α = 0.05) = 1.42

Q. Mean differences for variable V_{17} (total identification of quantitative signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.49	1.88*	2.17*
$\bar{X}_2$		-	1.39*	1.68*
$\bar{X}_3$			-	0.29
$\bar{X}_4$				-

HSD (α = 0.05) = 0.82

R. Mean differences for variable V_{18} (total comprehension of quantitative signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.78	6.01*	9.28*
$\bar{X}_2$		-	4.24*	7.51*
$\bar{X}_3$			-	3.26*
$\bar{X}_4$				-

HSD ($\alpha = 0.05$) = 2.31

S. Mean differences for variable V_{19} (total identification of cartographic signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.16	0.85*	1.08*
$\bar{X}_2$		-	0.68*	0.92*
$\bar{X}_3$			-	0.23
$\bar{X}_4$				-

HSD ($\alpha = 0.05$) = 0.37

T. Mean differences for variable V_{20} (total comprehension of cartographic signs)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.97*	4.49*	6.72*
$\bar{X}_2$		-	2.52*	4.75*
$\bar{X}_3$			-	2.23*
$\bar{X}_4$				-

HSD ($\alpha = 0.05$) = 1.46

U. Mean differences for variable V_{21} (grand total-competence in cartographic language)

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.06*	2.31*	3.69*
$\bar{X}_2$		-	1.25*	2.64*
$\bar{X}_3$			-	1.39*
$\bar{X}_4$				-
HSD (α = 0.05) = 0.97				

* significant at 0.05 level.

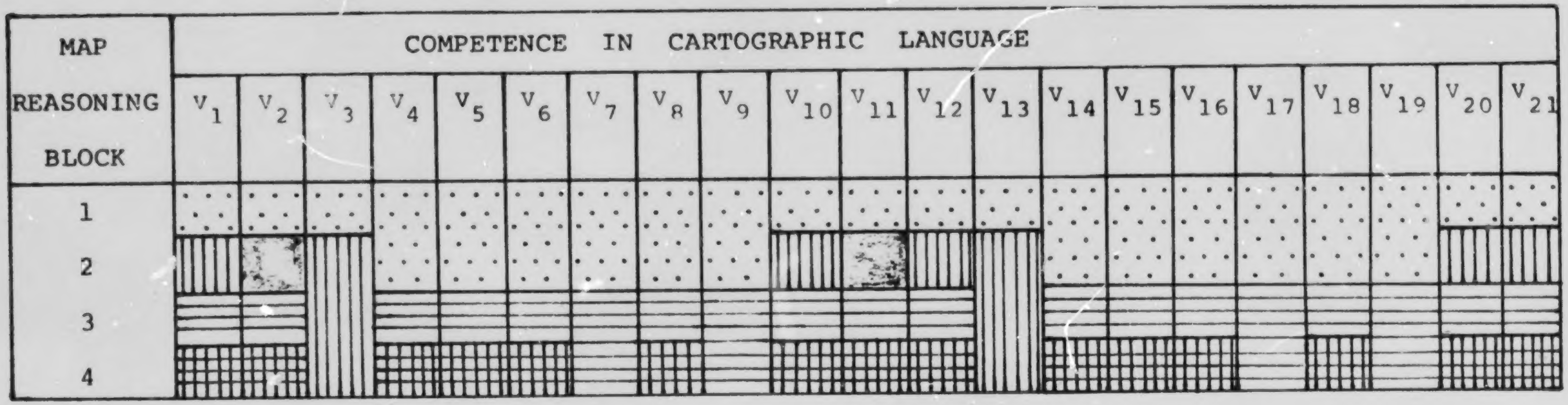
Table 33 indicates that 99 significant differences were found. The pattern of homogeneous subsets of blocks is illustrated in Figure 23. It indicates that there are fewer significant differences among the group means for the children's identification of cartographic signs. There is little difference between the group mean scores of children in blocks 1 and 2 in identifying all cartographic signs except for qualitative line and quantitative area signs. Similarly, there is little difference between the group mean scores of children in blocks 3 and 4 re their identification of cartographic signs, except for standard elements, quantitative line signs and qualitative area signs.

Figure 23 indicates that for children's comprehension of cartographic signs, the group mean scores for children in blocks 1 and 2 are similar, but significantly different from those of children in blocks 3 and 4. The scores of children in blocks 3 and 4 are significantly different from each other. Each of the four blocks is significantly different from the three other blocks on the children's comprehension of standard elements,

Table 31 STANDARD DEVIATIONS OF CHILDREN'S SCORES ON THEIR COMPETENCE IN CARTOGRAPHIC LANGUAGE BY MAP-REASONING BLOCKS

BLOCKS	RAW SCORE STANDARD DEVIATIONS											
	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}
1	2.11	5.00	2.19	5.05	1.10	3.30	2.38	4.64	1.47	3.67	2.10	5.01
2	2.09	6.60	1.83	5.72	0.97	3.47	2.49	6.08	1.06	4.07	2.09	6.61
3	2.48	7.11	1.41	5.93	1.17	3.45	1.59	5.66	0.96	3.28	2.48	7.11
4	2.57	6.78	1.01	5.85	1.11	3.11	1.33	5.45	0.93	2.82	2.57	6.78

BLOCKS	RAW SCORE STANDARD DEVIATIONS								
	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	V_{21}
1	2.19	5.05	1.10	3.30	2.38	4.63	1.14	3.67	2.14
2	1.83	5.72	0.97	3.47	2.49	6.08	1.05	4.07	2.44
3	1.41	5.93	1.17	3.46	1.59	5.66	0.96	3.28	2.33
4	1.01	5.85	1.10	3.11	1.33	5.45	0.93	2.82	1.87



Homogeneous Groups=Blocks which are significantly different from other blocks.

— = Divisions between homogeneous groups. ⁙ =Blocks homogeneous with Block 1

▥ = Blocks homogeneous with Block 2. ▤ = Blocks homogeneous with Block 3

▦ = Blocks homogeneous with Block 4. ▒ = Transition Area(overlap between homogeneous groups)

V_1=Identif. of Standard Elements;V_2=Comprehension of Standard Elements;V_3= Identif. of Qual.Line Sign; V_4=Comp. of Qual. Line Signs;V_5=Identif. of Quant. Line Signs;V_6=Comp. of Quant. Line Signs;V_7= Identif. of Qual. Point Signs;V_8= Comp. of Qual. Point Signs;V_9= Identif. of Quant. Point Signs; V_{10}= Comp. of Quant. Point Signs;V_{11}= Identif. of Qual. Area Signs;V_{12}= Comp. of Qual. Area Signs; V_{13}= Identif. of Quant. Area Signs;V_{14}= Comp.of Quant. Area Signs;V_{15}= Total Identif. of Qual. Signs;V_{16}= Total Comp. of Qual. Signs;V_{17}= Total Identif. of Quant. Signs;V_{18}= Total Comp. of Quant. Signs;V_{19}= Total Identif. of Signs;V_{20}= Total Comp. of Signs;V_{21}= Grand Total Competence Score.

Fig. 23 SUMMARY OF HOMOGENEOUS GROUPS AMONG BLOCKS OF SUBJECTS ON THEIR COMPETENCE IN CARTOGRAPHIC LANGUAGE

qualitative point signs and qualitative area signs.

Figure 23 also indicates that each of the four blocks is significantly different from the other blocks on the children's total score on competence in cartographic language.

These results are consistent with Piagetian notions of development. They suggest that the sequence of development of children's competence in cartographic language across the concrete level of map-reasoning is from block 1 through to block 4. Similarities between children in blocks 1 and 2 are noted. A detailed discussion of the implications of these results is given in Chapter 5.

Hypothesis 2 There is no difference between the mean performances of subjects in four map-reasoning levels for their performance in cartographic language.

The children's group mean scores and the standard deviations of their performance in cartographic language (V_1) are presented in Table 34. As indicated in Chapter 3.60, the children's performances were measured by two expert raters who scored the language the children used in their free-recall sketch maps of their school grounds.

Table 34 MEANS AND STANDARD DEVIATIONS OF CHILDREN'S SCORES ON THEIR PERFORMANCE IN CARTOGRAPHIC LANGUAGE

BLOCK	RAW SCORE MEANS V_1	RAW SCORE STANDARD DEVIATIONS V_1
1	2.89	1.18
2	3.43	1.07
3	4.00	0.79
4	4.35	0.76

Table 34 indicates that for the children's performance in cartographic language, the group means increase from block 1 through block 4. It also indicates that the difference between each pair of group means increases from block 1 to block 4.

Table 35 presents the results of the univariate analysis of variance for hypothesis 2.

Table 35 UNIVARIATE ANALYSIS OF VARIANCE USING CHILDREN'S PERFORMANCE IN CARTOGRAPHIC LANGUAGE.

VARIABLE	df	F	p
[illegible]	3	32.975	.0000**

** significant at 0.0001 level

The univariate F test reported in Table 35 indicates that there is a highly significant variation among the group means for all measured aspects of performance in cartographic language for children at the concrete level of map-reasoning.

Since the variance in the group mean scores of the children's performance in cartographic language produced a high F ratio with a p value less than 0.0001, the Tukey method of multiple comparisons was used to determine which groups are responsible for the significant F ratio on variable V_1 (performance in cartographic language). The mean differences among the four map-reasoning blocks and the appropriate HSD value for the dependent variable V_1 are presented in Table 36.

Table 36 MULTIPLE COMPARISONS FOR PERFORMANCE IN CARTOGRAPHIC LANGUAGE.

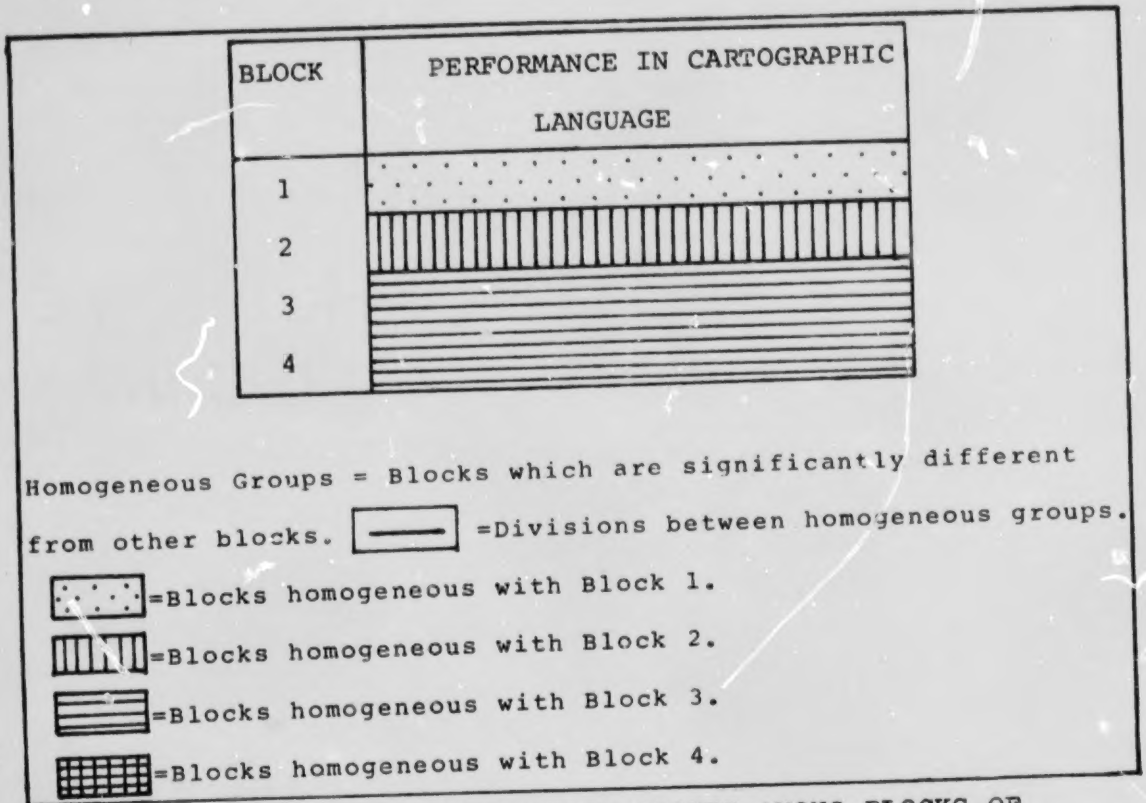
A. Mean differences for variable V_1 (performance in cartographic language).

Map-reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.53*	1.11*	1.46*
$\bar{X}_2$		-	0.57*	0.93*
$\bar{X}_3$			-	0.35
$\bar{X}_4$				-
HSD (α = 0.05) = 0.37				

* significant at 0.05 level.

Table 36 indicates that five significant differences were found at the 0.05 level. The pattern of homogeneous sub-sets is illustrated in Figure 24. It indicates that for the group means on children's performance in cartographic language, children in blocks 1 and 2 perform with significant difference from each other and from the children in blocks 3 and 4. However, children in blocks 3 and 4 are not significantly different from each other with respect to their performance in cartographic language.

These results suggest that there is a sequence of development in children's performance in cartographic language across the four concrete map-reasoning blocks. The sequence is from block 1 through blocks 3 and 4. A detailed discussion of the implications of these results is presented in Chapter 5.



Homogeneous Groups = Blocks which are significantly different from other blocks. ▭ =Divisions between homogeneous groups.

⁙ =Blocks homogeneous with Block 1.

▥ =Blocks homogeneous with Block 2.

▤ =Blocks homogeneous with Block 3.

▦ =Blocks homogeneous with Block 4.

Fig. 24 SUMMARY OF HOMOGENEOUS GROUPS AMONG BLOCKS OF SUBJECTS ON PERFORMANCE IN CARTOGRAPHIC LANGUAGE

The maps which the children drew of their school grounds illustrate the above pattern of performance in cartographic language. Salomon and Feldman(1969) stated that the concrete level of map-reasoning is surpassed only by the formal level of map-reasoning. Therefore, children at the concrete level of map-reasoning were expected to display some ability in using cartographic language.

Figures 25 to 28 illustrate the use of cartographic language in each of the four concrete map-reasoning blocks. The distinctive pattern in the children's representation of objects on a map is described below.

The cartographic language used by children in block 1 is sampled in Figure 25. The samples indicate that the cartographic signs used by these children consist of a blend of signals and mimetic symbols. Cartographic signals are evident when the children draw buildings from side or plan views. The side view of the school building is an attempted duplication of that view. Therefore, doors and stairs are inserted carefully on the school building. Where children draw buildings from a plan view, they attempt to duplicate the plan view of the roof, rather than to represent it. Therefore, they draw the corrugated iron together with its ridge capping.

Mimetic symbols,which retain the form of their referents, but which are distanced to a small extent from them, are drawn to represent key objects. The symbol for the school flag closely represents a flag flapping in the breeze. Trees, tennis nets, slippery slides, the incinerator and basketball goal posts,are other objects represented by mimetic symbols.

Children in block 1 do not use a legend. They prefer to verbalise on the map, e.g. the location of the school bell. They verbalise at the expense of the clarity of the map.

Children in block 2 make a similar use of cartographic language to those in block 1. However, there is evidence of the children starting to insert increased distance between the sign and the referent. Children in block 2 also begin to use a legend and a direction indicator. The cartographic language used by children in block 2 is sampled in Figure 26. It reveals that some children in block 2 still draw cartographic signals

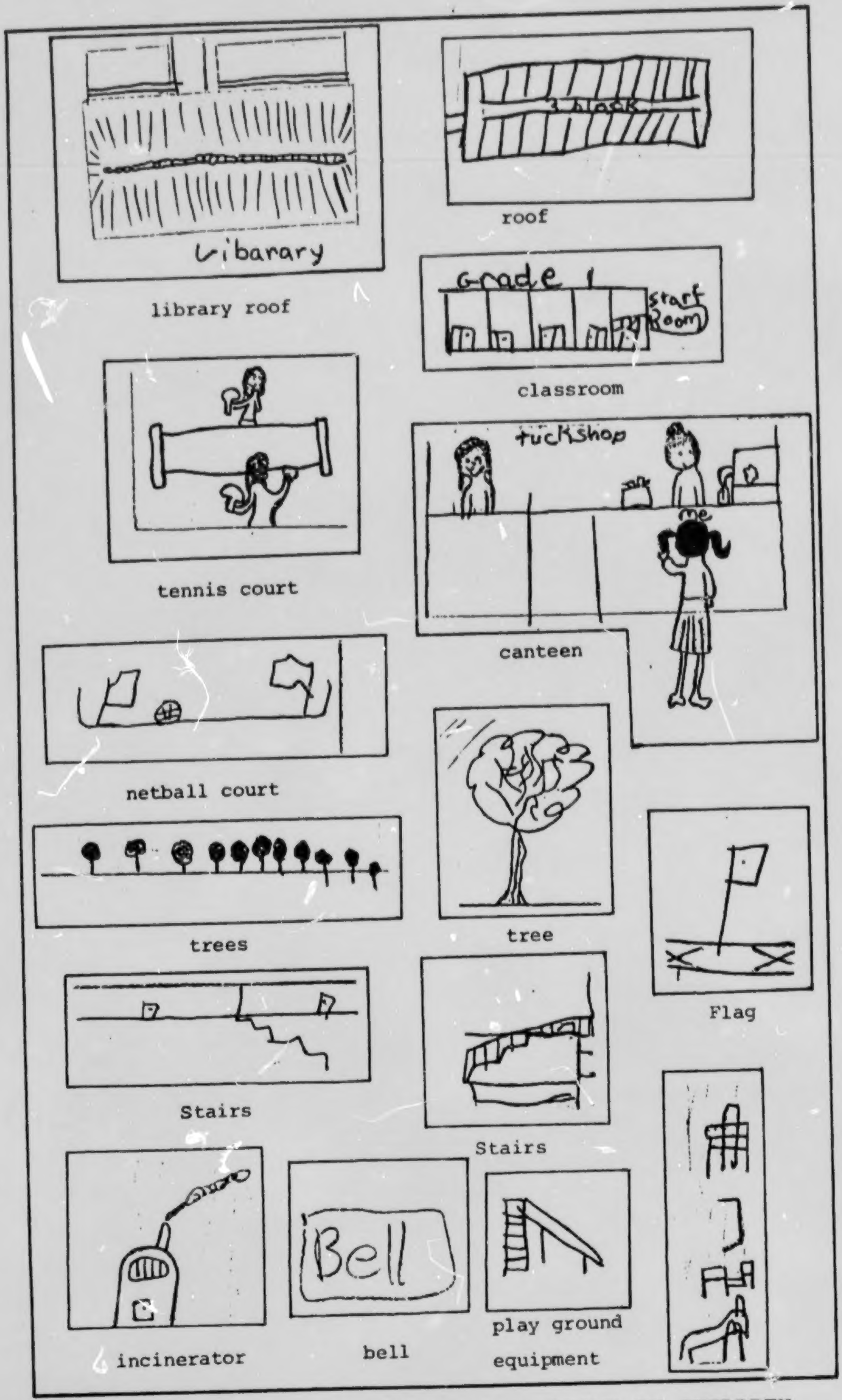

Libarary
library roof
3 block
roof
Grade 1
Starf Room
classroom
tennis court
tuckshop
me
canteen
netball court
trees
tree
Flag
Stairs
Stairs
incinerator
Bell
bell
play ground equipment

Fig.25 SELECTED CARTOGRAPHIC SIGNS DRAWN BY CHILDREN IN MAP-REASONING BLOCK 1

to depict buildings. Whereas children in block 1 insert details of doors and stairs on their drawings of buildings, those in block 2 insert more detail, e.g. windows.

Children in block 2 present a larger range of mimetic symbols on their maps. Trees, incinerator, bell and playground equipment are represented as well as gates and fences. These children also begin to use a legend and a direction indicator. The signs presented in the legend are mainly mimetic. However, the children still verbalise on their maps, even when they use a legend. Therefore, the maps of children in blocks 1 and 2 are cluttered with names.

Children in block 3 generally draw less cluttered maps than those in the lower map reasoning blocks. This is because of the decrease in the amount of verbalising on the maps.

The signs on the maps of children in block 3 are all symbols of sorts. (see Figure 27). Mimetic symbols are present in the signs for the school bell, trees and school gates. This type of sign constitutes a minority of the signs used on the maps. An increasing number of the signs are distant from their referents. Buildings are drawn as geometric shapes (squares or rectangles) and are usually identified by label, e.g. typing room. The increasing abstractness of signs is best illustrated by referring to particular objects: the school fence is represented somewhat like a railway line; the incinerator is a small square; trees are classified as plants or vegetation and represented by wiggly circular symbols; and playground equipment is represented by small rectangular shapes.

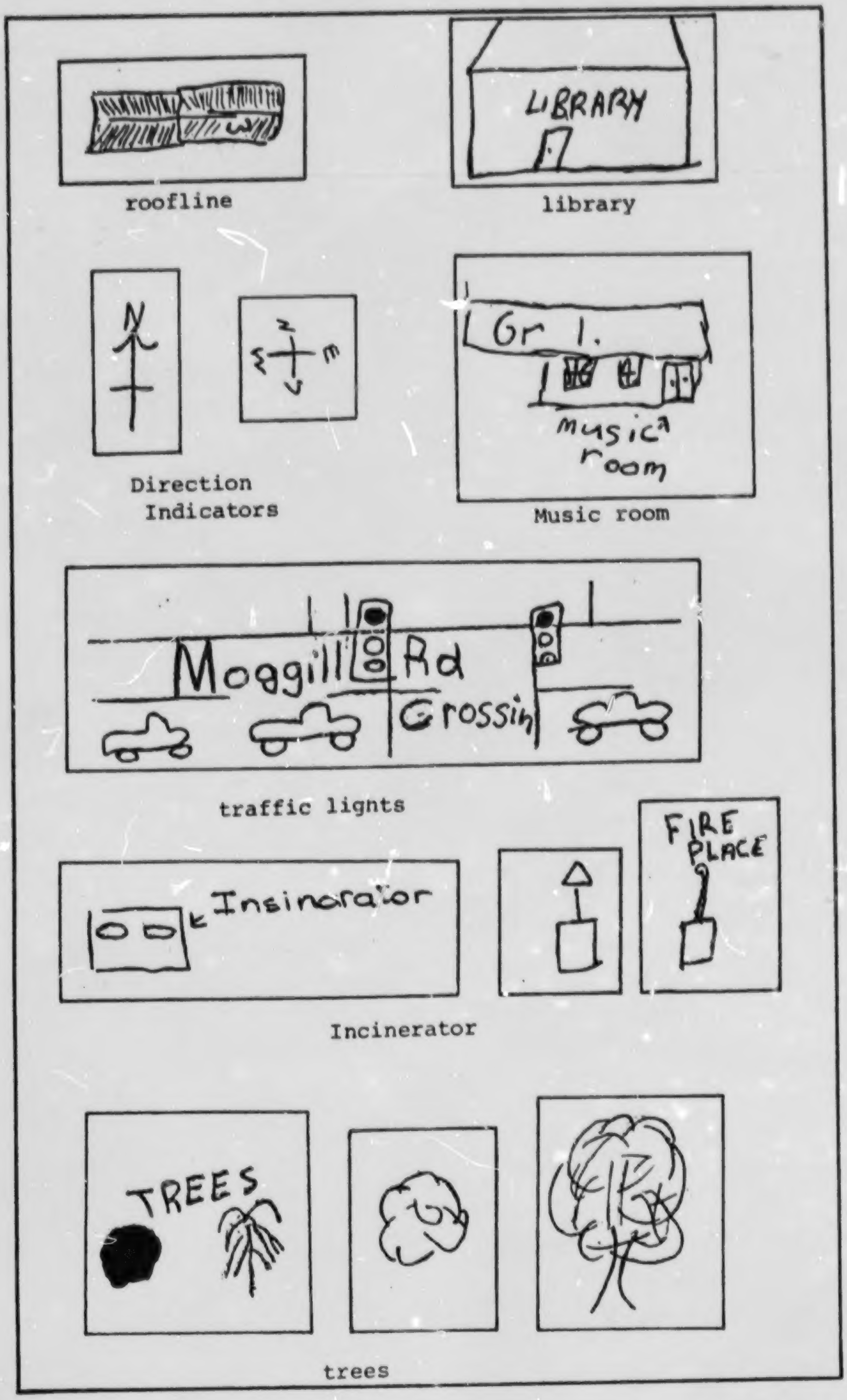
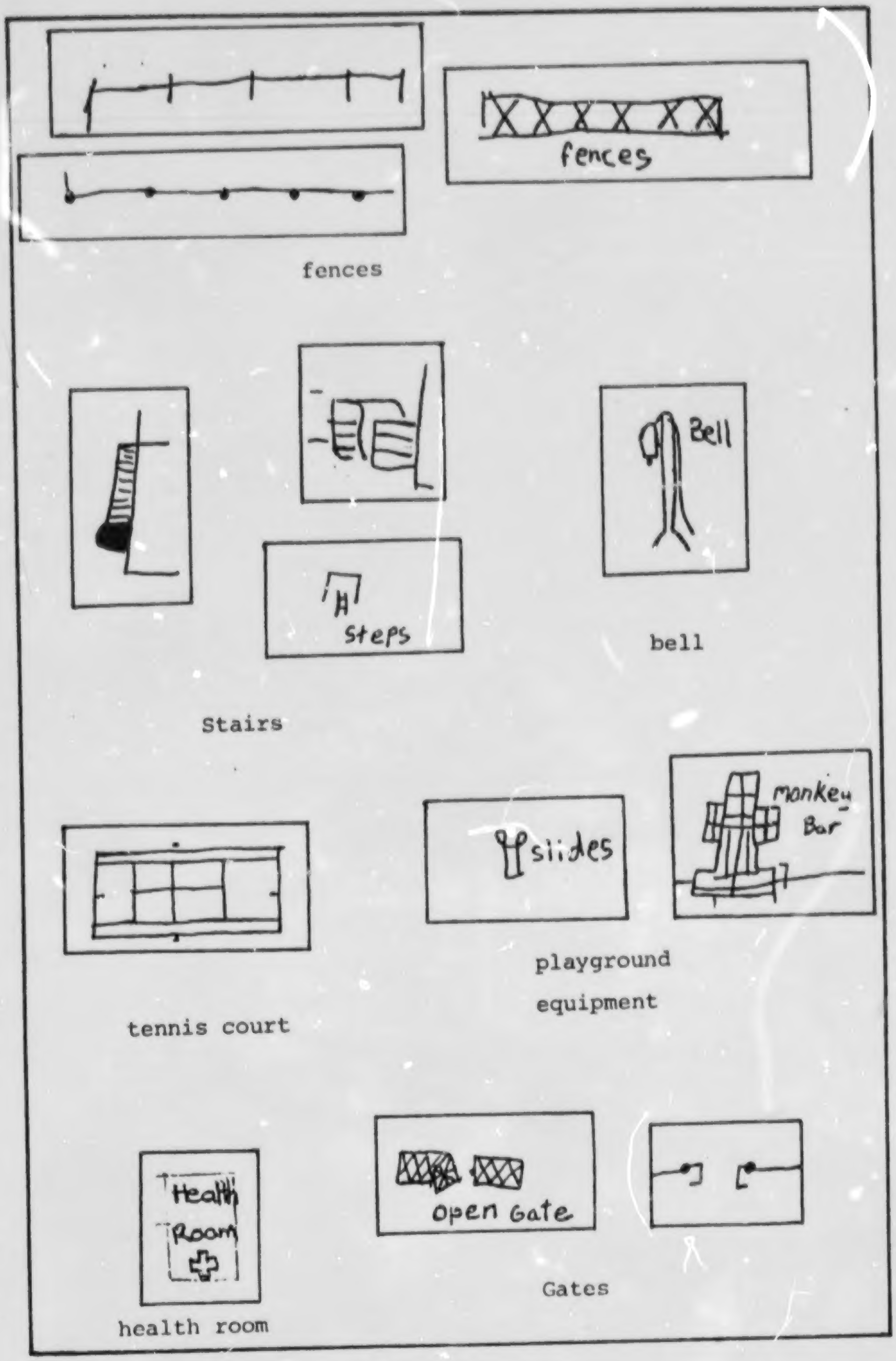

LIBRARY
roofline
library
N
Gr 1.
music room
Direction Indicators
Music room
Moggill Rd
Crossin
traffic lights
Insinarator
FIRE PLACE
Incinerator
TREES
trees

Fig. 26 SELECTED CARTOGRAPHIC SIGNS DRAWN BY CHILDREN IN MAP-REASONING BLOCK 2


fences
fences
Bell
steps
Stairs
bell
slides
monkey Bar
tennis court
playground equipment
Health Room
open Gate
health room
Gates

(Figure 26 continued)

Children in block 3 make no more use of the direction indicator than those in block 2. They do make greater use of a legend. This is so for line, point and area signs. They also use colour, in a limited way, to discriminate between signs of similar shape.

The maps of children in block 4 display increasingly sophisticated use of cartographic language. Most of the signs on these maps are abstract, bearing little visual resemblance to their referents. This increased distance between sign and referent is most prevalent in the maps of children in block 4. For example, the school is represented by a black dot, a tar or bitumen area by stippled shading and the school fence by a linear pattern. Children in block 4 have encoded more information on their maps because the symbols they use are smaller and indicate the general location of objects rather than the exact location of point referents. Therefore, trees are represented by small dots rather than large circular patterns.

The maps of children in block 4, like those of children in block 3, are relatively uncluttered because of the size of the cartographic signs used and the more careful selection of cartographic information. The labelling and verbalising of the earlier blocks is confined in block 4 to the identification of key school buildings and playing areas (see Figure 28).

The children in block 4 make greater use of the direction indicator, legend and colour in their maps. They draw the direction indicator as a north point or as a representation of the cardinal points. The legends

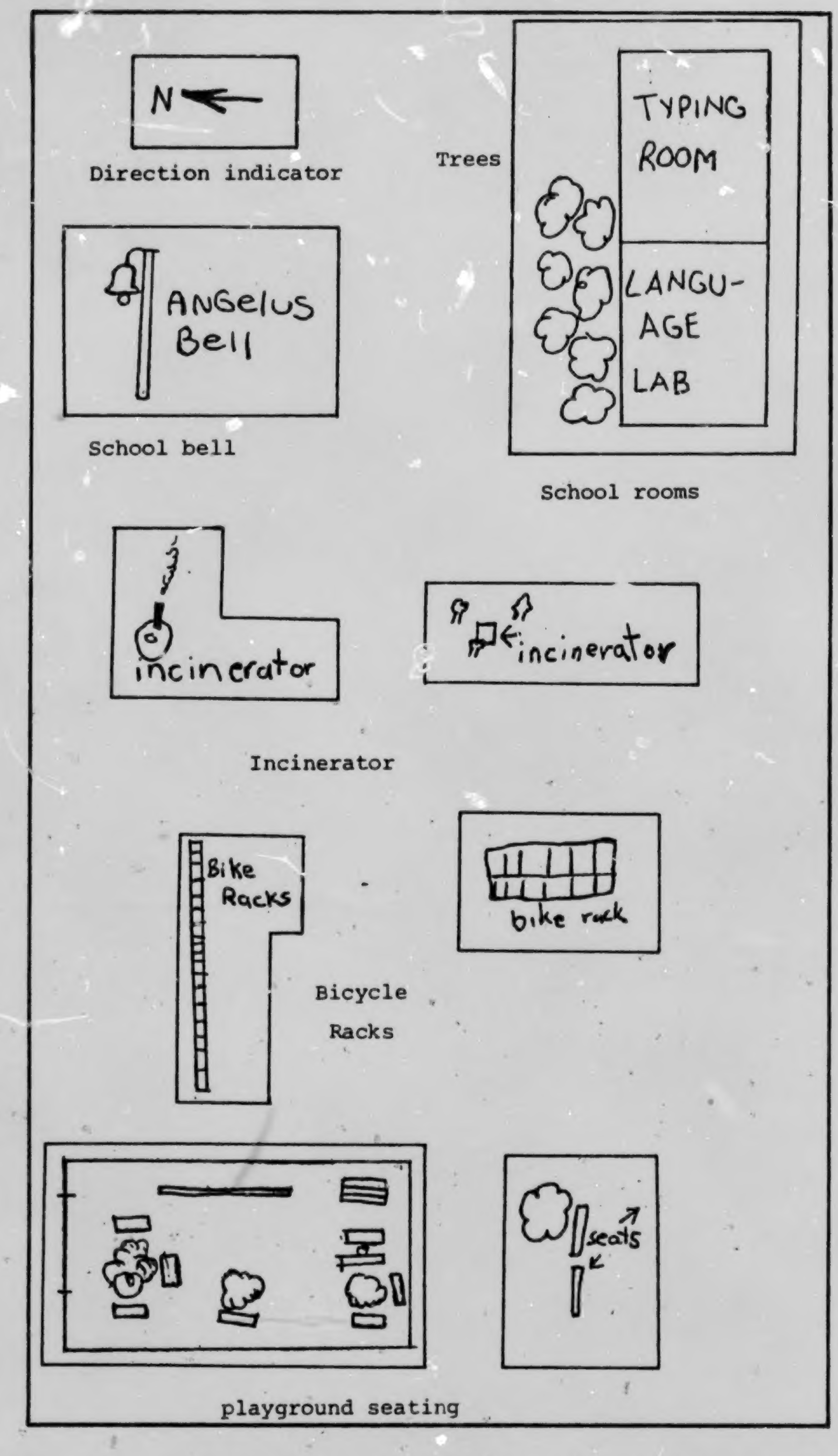
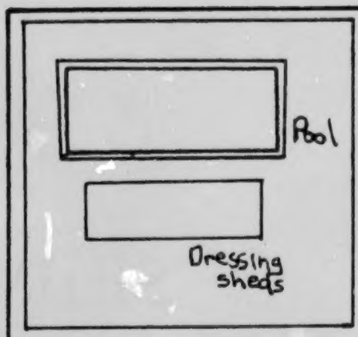
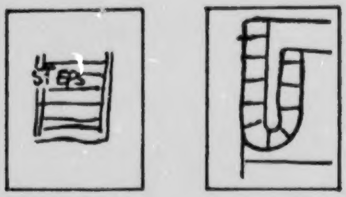

N
Direction indicator
Trees
TYPING ROOM
LANGU-AGE LAB
ANGelUS Bell
School bell
School rooms
incinerator
incinerator
Incinerator
Bike Racks
bike rack
Bicycle Racks
seats
playground seating

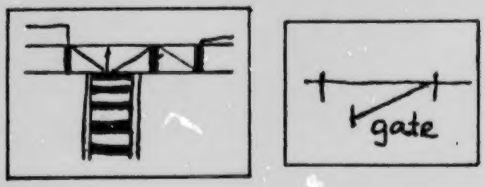
Fig. 27 SELECTED CARTOGRAPHIC SIGNS DRAWN BY CHILDREN IN MAP-REASONING BLOCK 3


Pool
Dressing sheds

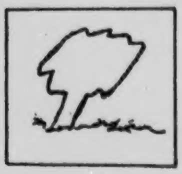
swimming pool



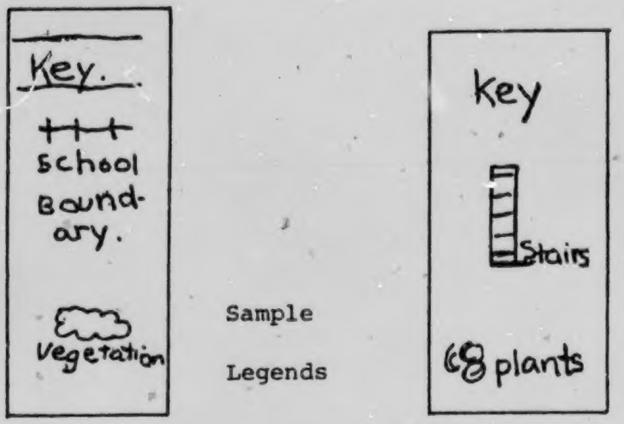
Stairs



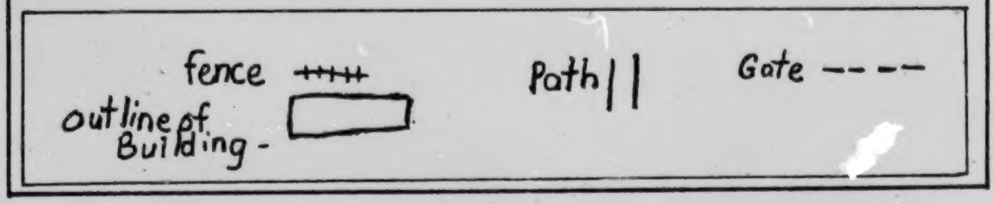
school gate and
pedestrian crossing



trees


Key.
school Boundary.
Vegetation
Key
Stairs
plants

Sample
Legends


fence
Path
Gate
outline of Building -

(Figure 27 continued)

for the maps are comprehensive and occupy considerable area on the map page. The increased use of colour in cartographic signs is pronounced. The colours are used in a conventional sense, e.g. green for natural vegetation and blue for water. They also discriminate between signs of similar shape, e.g. types of buildings.

The characteristics of the cartographic signs used by children in each of the four blocks of concrete map-reasoning are summarised in Table 37 and in Figures 29 and 30.

Table 37 CHARACTERISTICS OF CARTOGRAPHIC SIGNS USED BY CHILDREN IN FOUR MAP-REASONING BLOCKS

VARIABLE	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4
Signals	Common	Some	Nil	Nil
Mimetic Symbols	Some	Common	Some	Nil
Abstract Symbols	Nil	Nil	Some	Common
Verbalisation	Common	Common	Some	Some
Legend	Nil	Occasional	Common	Common
Direction Indicator	Nil	Occasional	Occasional	Common
Colour in Signs	Nil	Nil	Occasional	Common

Nil = no evidence

Some = evident characteristic

Occasional = infrequent characteristic

Common = widespread characteristic

Table 37, together with Figures 29 and 30, indicates that there is a sequence in the children's use of cartographic signs across the four concrete map-reasoning levels. Children at the lower end of the sequence (block 1) use mostly cartographic signals, a large amount of verbalisation, and no legend, direction indicator or colour. Children in block 2 use mostly

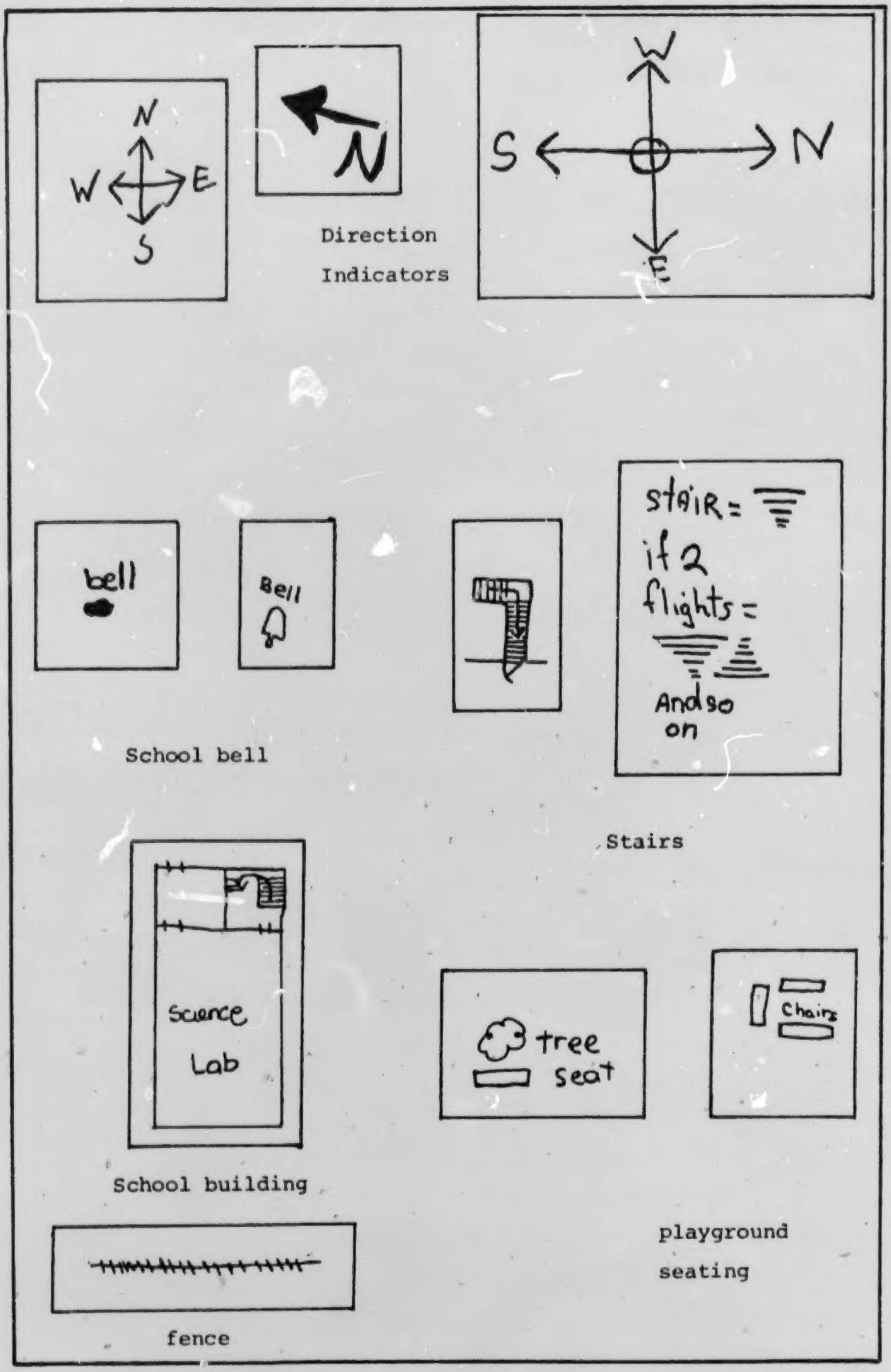
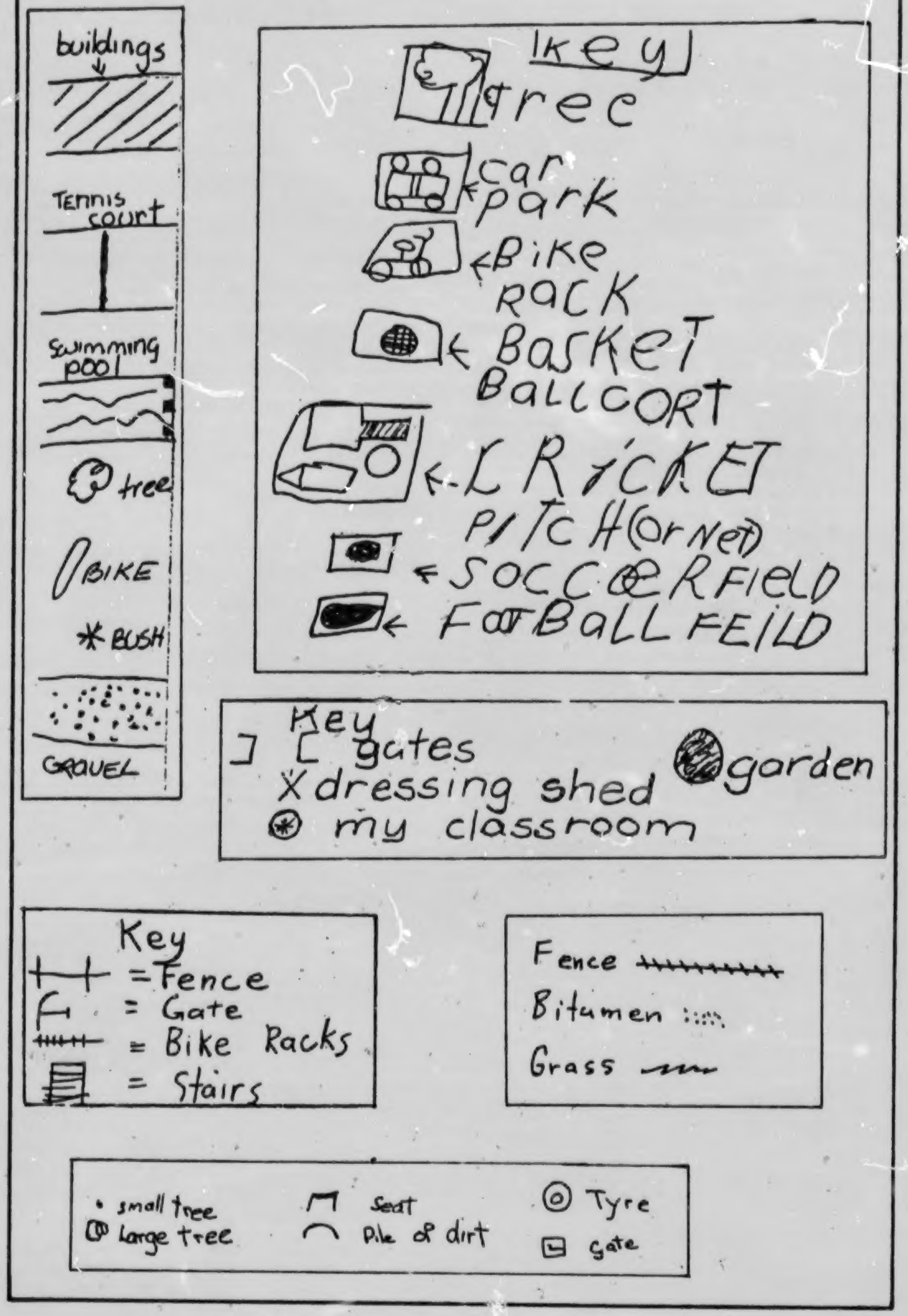
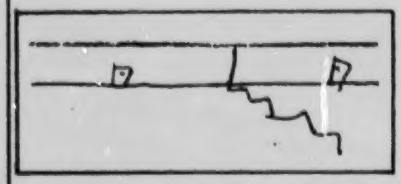

N
W
E
S
N
W
S
N
E
Direction Indicators
bell
Bell
stAiR =
if 2 flights =
And so on
School bell
Stairs
Science Lab
School building
tree
seat
Chairs
playground seating
fence

Fig. 28 SELECTED CARTOGRAPHIC SIGNS DRAWN BY CHILDREN IN MAP-REASONING BLOCK 4

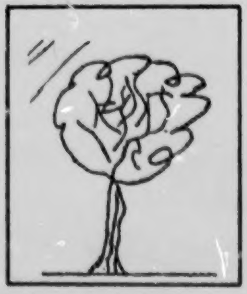
Sample legends


buildings
Tennis court
swimming pool
tree
BIKE
BUSH
GRAVEL
Key
tree
car park
Bike RacK
BasKeT BaLLCORT
CRiCKET PITCH (or Net)
SOCCERFIELD
FooTBaLL FEILD
Key
gates
garden
dressing shed
my classroom
Key
= Fence
= Gate
= Bike Racks
= Stairs
Fence
Bitumen
Grass
small tree
Large tree
Seat
Pile of dirt
Tyre
gate

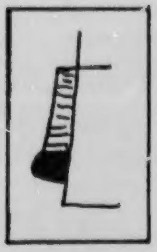
(Figure 28 continued)



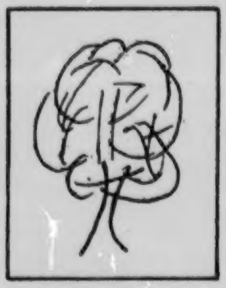
stairs (1)



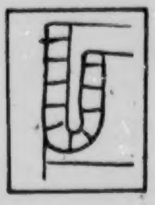
tree (1)



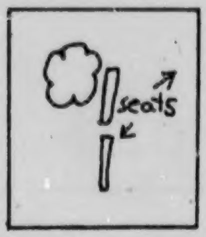
stairs (2)



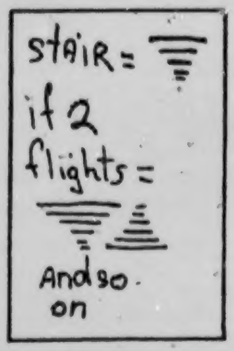
tree (2)



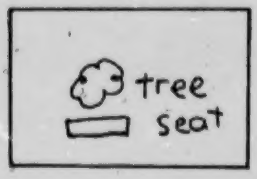
stairs (3)



tree and seats (3)

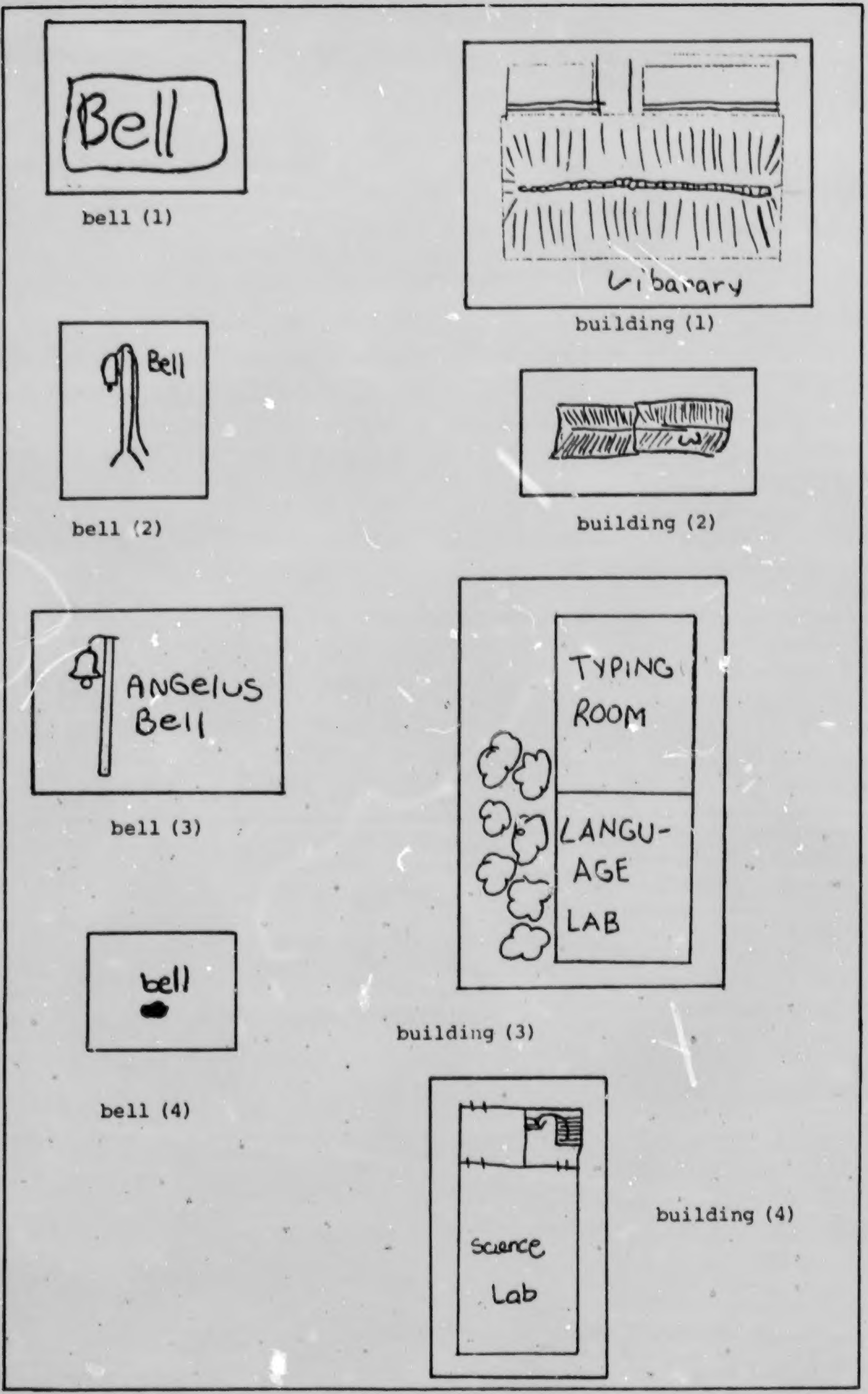

stAiR =
if 2
flights =
And so
on

stairs (4)



tree and seat (4)

Fig. 29 SEQUENCE OF CARTOGRAPHIC SIGNS FOR STAIRS AND TREES DRAWN BY CHILDREN IN FOUR CONCRETE MAP-REASONING LEVELS


Bell
Libarary
Bell
ANGelus Bell
bell
TYPING ROOM
LANGU-AGE LAB
Science Lab

bell (1)

building (1)

bell (2)

building (2)

bell (3)

building (3)

bell (4)

building (4)

Fig. 30 SEQUENCE OF CARTOGRAPHIC SIGNS FOR BELL AND BUILDINGS DRAWN BY CHILDREN IN FOUR CONCRETE MAP-REASONING LEVELS

mimetic symbols, a large amount of verbalisation, limited use of a legend and direction indicator, and no colour. The children in block 3 use a blend of mimetic and abstract symbols, some verbalisation, a legend, and occasional evidence of colour and a direction indicator. Finally, children in block 4 use abstract symbols, which are decoded in a legend. They use colour in a conventional sense and as a discriminator. Some verbalisation is evident in their labelling of buildings and playing fields. Direction indicators are used widely.

The above results concerning children's performance in cartographic language are consistent with Piagetian notions of development. They suggest that the developmental blocks across the concrete level of map-reasoning are sequential from block 1 through block 4. A detailed discussion of the implications of these results is given in Chapter 5.

4.2 Testing of the hypothesis associated with the multivariate design.

The hypothesis considered in this part is presented below in null form for reference purposes:

Hypothesis 3. There is no difference between the mean performances of subjects in four map-reasoning levels for three map design variables (colour in cartographic signs, map generalisation and map lettering) and ten map user variables (age, map-reading ability, home environment, previous experience with maps, understanding the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence and spatial ability). This hypothesis is associated with question 3 in Chapter 1.

The results of the reliability studies performed on variables V_1 to V_3 and V_5 to V_{13} were presented in Chapter 3. Reliabilities for all of these variables except V_7 (previous experience with maps) are high. Hence, the reliability data support the interpretation of results in this section.

A multivariate design was used since:

(a) the children's scores across the four map-reasoning blocks were expected to be correlated, and

(b) it was expected that the scores in these blocks would have differential effects on the three map design variables and the ten map user variables.

A 4 X 13 multivariate randomised block design is used with the children's map-reasoning level acting as the blocking variable. The procedures outlined in Chapter 3 indicated that the children were selected randomly from each of the four concrete map-reasoning blocks so that 75 children remained in each of the four blocks. Therefore, the assumptions underlying a randomised block design were met.

The data analyses for this part of the study were performed using the NYBMUL linear multivariate analysis computer program devised by Finn (1972) and elaborated by Finn and Mattsson (1974). The NYBMUL program was used to calculate the following statistics for the above hypothesis: (a) an overall F ratio for the multivariate test of equality of mean vectors; (b) a set of standardised discriminant coefficients for each variable; and (c) a series of univariate statistics for each of the dependent variables. A discriminant function is reported and discussed for the hypothesis in which the overall F ratio indicates that a significant variation occurred among the mean vectors. Multiple comparisons are reported when univariate F ratios indicate significant differences between group means.

The mean scores and standard deviations on the thirteen dependent variables across the four concrete map-reasoning levels are presented in Tables 38 and 39.

Table 38 indicates that there is a gradual increase in the group mean scores from block 1 through block 4 for the three map design variables and the following map user variables: V_4 (age), V_6 (home environment), V_7 (previous experience with maps), V_8 (understanding the concept of a map), V_9 (drawing ability), V_{11} (nonverbal intelligence), V_{12} (verbal intelligence) and V_{13} (spatial ability). For these variables, the differences between the group mean scores increase from block 1 through block 4 for variables V_4, V_6, V_8, V_{11} and V_{12}. The largest difference between the group mean scores is between blocks 1 and 2, followed by blocks 3 and 4, for variables V_1, V_2, V_3 and V_{13}. For variables V_7 and V_9, the largest difference between group mean scores is between blocks 3 and 4, followed by blocks 1 and 2.

Table 40 presents the results of the multivariate analysis of variance, discriminant analysis and univariate analysis of variance for hypothesis 3.

V_1= Colour in Cartographic Signs; V_2= Map Generalisation; V_3= Map Lettering; V_4= Age; V_5= Map-Reading Ability; V_6= Home Environment; V_7= Previous Experience with Maps; V_8= Understanding the Concept of a Map; V_9= Drawing Ability; V_{10}= Attitudes to Maps; V_{11}= Non Verbal Intelligence; V_{12}= Verbal Intelligence; V_{13}= Spatial Ability.

Table 38 GROUP MEAN SCORES OF DEPENDENT VARIABLES BY MAP-REASONING BLOCKS

BLOCKS	RAW SCORE MEANS												
	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}
1	3.56	15.39	13.60	8.95	48.97	29.16	10.56	4.61	4.79	44.41	115.85	108.25	44.57
2	4.39	21.05	17.93	10.12	51.65	29.16	10.80	5.03	6.03	43.57	117.29	108.95	47.97
3	4.76	19.21	18.80	11.51	58.30	29.58	11.59	5.19	6.99	44.73	118.93	111.32	48.79
4	5.19	23.43	21.97	13.12	58.18	30.49	12.72	6.27	9.20	41.49	121.06	115.57	51.48

Table 39 STANDARD DEVIATIONS OF DEPENDENT VARIABLES BY MAP REASONING BLOCKS

BLOCKS	RAW SCORE STANDARD DEVIATIONS												
	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}
1	1.66	6.24	6.56	0.43	17.52	4.58	3.12	1.35	2.59	7.29	12.49	8.04	3.87
2	1.82	4.66	4.79	0.51	17.67	5.12	2.74	1.51	2.42	6.05	12.83	9.83	4.99
3	1.82	6.62	6.91	0.57	16.11	5.05	2.64	1.49	3.26	5.96	15.94	11.00	3.64
4	1.81	4.43	3.27	0.85	13.92	3.99	2.65	1.64	2.56	7.89	10.79	9.96	3.48

Table 40 MULTIVARIATE AND UNIVARIATE ANALYSIS OF VARIANCE FOR HYPOTHESIS 3 USING THREE MAP DESIGN AND TEN MAP USER VARIABLES.

VARIABLE(S)	TEST	df	F	p
$V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_{10}, V_{11}, V_{12}, V_{13}$.	M	835	17.98	.0001**
V_1	U	39	2.09	.1
V_2	U	39	9.11	.0001**
V_3	U	39	3.46	.01*
V_4	U	39	283.40	.0001**
V_5	U	39	61.86	.0001**
V_6	U	39	3.57	.01*
V_7	U	39	0.56	.64
V_8	U	39	0.79	.5
V_9	U	39	5.04	.002*
V_{10}	U	39	1.81	.15
V_{11}	U	39	38.73	.0001**
V_{12}	U	39	45.18	.0001**
V_{13}	U	39	1.69	.16

Discriminant function, map-reasoning level.

$$V_1 \text{ Map-Reasoning} = .0V_1 + .18V_2 - .08V_3 - .93V_4 + .27V_5 + .17V_6 + .04V_7 - .06V_8 - .01V_9 - .16V_{10} + .1V_{11} - .07V_{12} - .01V_{13}$$

$$V_2 \text{ Map-reasoning} = .18V_1 + .38V_2 + .18V_3 - .23V_4 + .39V_5 - .07V_6 - .05V_7 - .09V_8 - .03V_9 + .11V_{10} - .4V_{11} - .8V_{12} + .46V_{13}.$$

* significant at 0.01 level ** significant at 0.0001 level

3/3

The multivariate F test reported in Table 40, indicates that there is a highly significant variation among the mean vectors for map-reasoning level with a p value less than 0.0001. Since the variation among mean vectors for map reasoning level is significant, there is a significant discriminant function for map-reasoning level. Two discriminant functions are presented in Table 40. They indicate the linear function of the dependent variables which discriminate maximally between the four map-reasoning blocks in a least squares sense. The first linear function (V_1) accounts for 90.99 per cent of the canonical variation. The second linear function (V_2) accounts for 6.73 per cent of the canonical variation. Therefore, the discriminant function provides a means of characterising multivariate differences among the four map-reasoning blocks.

The discriminant function accounting for 90.99 per cent of the canonical variation is:

$$\begin{aligned} V_1 \text{ map-reasoning} = {} & 0.0V_1 + 0.18V_2 - 0.08V_3 - 0.93V_4 + 0.27V_5 \\ & + 0.17V_6 + 0.04V_7 - 0.06V_8 - 0.01V_9 - 0.16V_{10} \\ & + 0.1V_{11} - 0.07V_{12} - 0.01V_{13}. \end{aligned}$$

The discriminant function accounting for 6.73 per cent of the canonical variation is:

$$\begin{aligned} V_2 \text{ map-reasoning} = {} & 0.18V_1 + 0.38V_2 + 0.18V_3 - 0.23V_4 + 0.39V_5 \\ & - 0.07V_6 - 0.05V_7 - 0.09V_8 - 0.03V_9 \\ & + 0.11V_{10} - 0.4V_{11} - 8V_{12} + 0.46V_{13}. \end{aligned}$$

The coefficients are written in standardised form. Therefore, they represent how much or how little each variable contributes to the differentiation between the four map-reasoning blocks. Tatsuoka (1970:4) observes that there may be discrepancies between the conclusions reached from a discriminant analysis and a series of discrete univariate analyses of the corresponding variables since each standardised weight represents the relative importance of that variable with the effects of other variables partialled out. The main discriminant analysis (accounting for 90.99 per cent of the canonical variation) indicates that V_2 (map generalisation) V_5 (map-reading ability), V_6 (home environment) and V_{11} (nonverbal intelligence) contribute most in a positive sense to the discrimination between the four concrete map-reasoning blocks. It also indicates that variables V_4 (age) and V_{10} (attitudes to maps) contribute most in a negative sense. There are two directions of discrimination in the discriminant function of V_1 map-reasoning. The first direction is that of: V_2 (map generalisation), V_5 (map-reading ability),V_6 (home environment)and V_{11} (nonverbal intelligence). The second direction is dominated by V_4 (age) and includes V_3 (map lettering), V_8 (understanding the concept of a map), V_9 (drawing ability), V_{10} (attitudes to maps), V_{12} (verbal intelligence) and V_{13} (spatial ability). Most of the variables in the second direction are characterised by group mean scores which increase from block 1 through block 4. Most of the variables in the first direction (except for home environment) are not characterised by such an orderly pattern of group mean scores. Since V_4 (age) is the dominant discriminant coefficient and since the variables with negative discriminant coefficients have group means which increase along with the ages of the children in the study group, variable V_4 (age) is a major influence in children's map-reasoning level.

However, this influence is in a different direction from those of variables such as V_2(map generalisation), V_5 (map-reading ability) and V_6 (home environment). The second discriminant function is included, not because it contributes 6.73 per cent to the canonical variation, but because it is significant and its coefficients clarify some of the neutral discriminant coefficients. Variables V_1 (colour), V_2 (map generalisation) and V_{13} (spatial ability), have stronger positive tendencies, while variables V_7 (previous experience with maps), V_{11} (nonverbal intelligence) and V_{12} (verbal intelligence) have stronger negative tendencies.

While discriminant analysis is generally the preferred technique following a multivariate analysis of variance, Cramer and Bock (1966: 605) declare that a significant multivariate statistic justifies an investigation of discrete univariate F tests for the corresponding variables. Therefore, a series of analyses of variance were performed on each dependent variable, V_1 through to V_{13}. The results of these analyses are presented in Table 41. There are highly significant differences among the group means with p values less than 0.0001 for the following variables: V_2 (map generalisation), V_4 (age), V_5 (map-reading ability), V_{11} (nonverbal intelligence and V_{12} (verbal intelligence). There are significant differences among the group means with p values less than 0.01 for the following variables: V_3 (map lettering), V_6 (home environment), and V_9 (drawing ability). There are no significant differences among the group means for V_1 (colour in cartographic signs), V_7 (previous experience with maps), V_8 (understanding the concept of a map), V_{10} (attitudes to maps), and V_{13} (spatial ability).

The Tukey method of multiple comparisons was used to decide which groups are responsible for the significant F ratios on each of the following significant dependent variables: V_2 (map generalisation), V_3 (map lettering), V_4 (age), V_5 (map-reading ability), V_6 (home environment), V_9 (drawing ability), V_{11} (nonverbal intelligence)and V_{12} (verbal intelligence). The differences between the pairs of group mean scores and the appropriate HSD values for each of the above dependent variables are presented in Table 41.

Table 41 MULTIPLE COMPARISONS FOR THE SIGNIFICANT VARIABLES ON THE UNIVARIATE TESTS.

A. Mean differences for variable V_2 (map generalisation)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	3.25*	6.93*	8.76*
$\bar{X}_2$		-	3.68*	5.51*
$\bar{X}_3$			-	1.83
$\bar{X}_4$				-

HSD (α = 0.05) = 2.26

B. Mean differences for variable V_3 (map lettering)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	2.82*	8.01*	9.27*
$\bar{X}_2$		-	5.2*	6.46*
$\bar{X}_3$			-	1.25
$\bar{X}_4$				-

HSD (α = 0.05) = 2.13

C. Mean differences for variable V_4 (age)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.17*	2.56*	4.17*
$\bar{X}_2$		-	1.39*	2.99*
$\bar{X}_3$			-	1.61*
$\bar{X}_4$				-

HSD ($\alpha = 0.05$) = 0.63

D. Mean differences for variable V_5 (map-reading ability)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	2.68	9.22*	9.33*
$\bar{X}_2$		-	6.53	6.65
$\bar{X}_3$			-	0.12
$\bar{X}_4$				-

HSD ($\alpha = 0.05$) = 7.05

E. Mean differences for variable V_6 (home environment)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	.48	1.63	3.15*
$\bar{X}_2$		-	1.15	2.67*
$\bar{X}_3$			-	1.52
$\bar{X}_4$				-

HSD ($\alpha = 0.05$) = 1.94

F. Mean differences for variable V_9 (drawing ability)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.8	2.07*	3.47*
$\bar{X}_2$		-	1.27*	2.67*
$\bar{X}_3$			-	1.40*
$\bar{X}_4$				-
HSD (α = 0.05) = 1.21				

G. Mean differences for variable V_{11} (nonverbal intelligence)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	1.44	30.8	5.21*
$\bar{X}_2$		-	1.64	3.77
$\bar{X}_3$			-	2.13
$\bar{X}_4$				-
HSD (α = 0.05) = 4.88				

H. Mean differences for variable V_{12} (verbal intelligence)

Map-Reasoning	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
$\bar{X}_1$	-	0.69	3.07	7.31*
$\bar{X}_2$		-	2.38	6.62*
$\bar{X}_3$			-	4.24*
$\bar{X}_4$				-
HSD (α = 0.05) = 4.21				

* Significant at 0.05 level

Table 41 indicates that 29 significant differences have been located. The pattern of homogeneous subsets of blocks is illustrated in Figure 31. Figure 31 indicates that for the two significant map design variables - map generalisation and map lettering - the performances of children in blocks 1 and 2 are significantly different from each other and from that of children in blocks 3 and 4. The group means of the performances of children in blocks 3 and 4 are homogeneous. The pattern is not as clear for the map user variables: age, map-reading ability, home environment, drawing ability, nonverbal and verbal intelligence. For age and verbal intelligence, the group mean scores in each block are significantly different from those in the other three blocks. However, for map-reading ability, the mean scores of children in block 1 are significantly different from those of children in blocks 3 and 4; for home environment, the mean scores of children in block 1 are significantly different from those in blocks 2, 3 and 4; for drawing ability, the mean scores of children in blocks 1 and 2 are significantly different from those of children in blocks 3 and 4 which are significantly different from each other; and for nonverbal intelligence where the mean scores of children in block 4 are significantly different from those of children in the three other blocks.

The discriminant analyses indicate the two main planes of influence of the three map design variables and the ten map user variables. Age dominates one of these planes of influence and map-reading ability the other. The univariate analyses and multiple comparisons analyses indicate for which variables there are significant

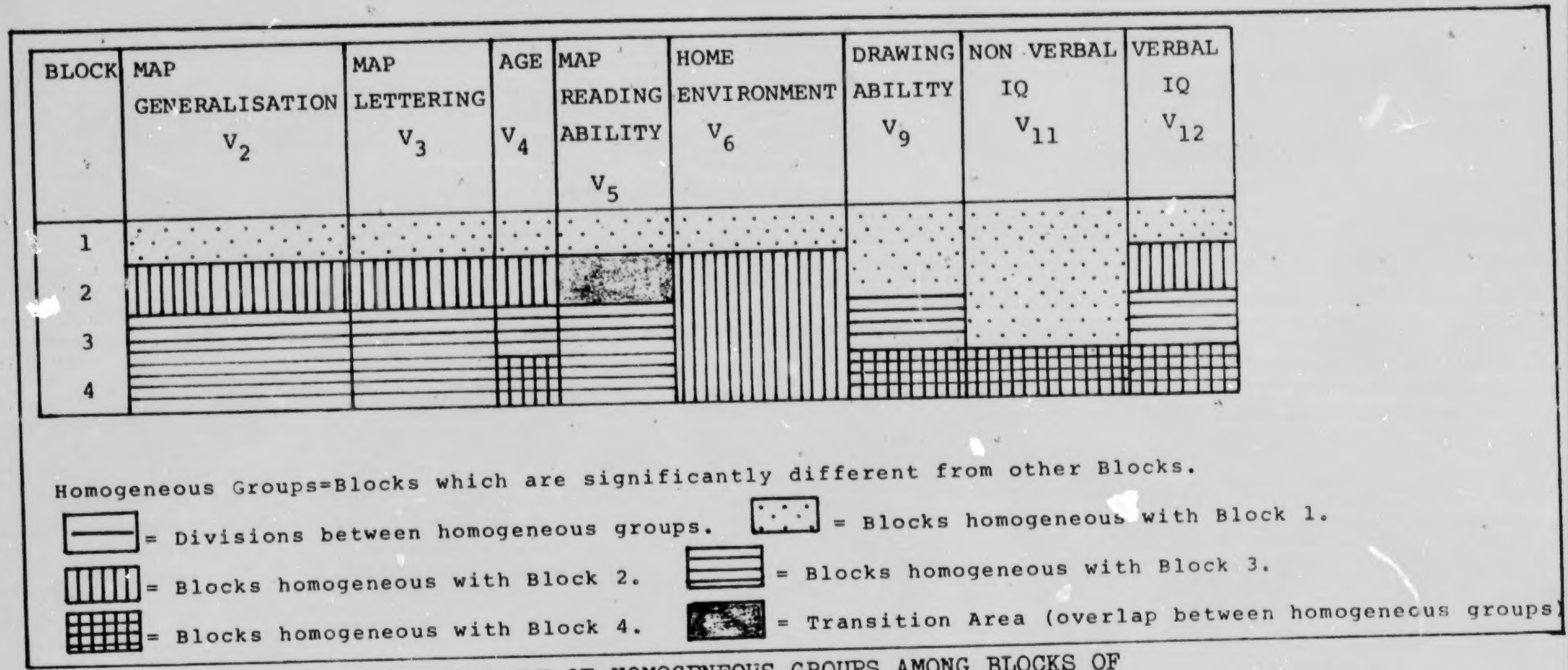


Fig. 31 SUMMARY OF HOMOGENEOUS GROUPS AMONG BLOCKS OF SUBJECTS ON SIGNIFICANT MAP DESIGN AND MAP USER VARIABLES

differences and between which group mean scores the differences are significant. The variables with most significant differences between pairs of group means are: map generalisation,age, map lettering, drawing ability, and verbal intelligence.

These results are consistent with Piagetian notions of development and they suggest that the developmental blocks across the concrete level of map-reasoning are sequential from block 1 through block 4, although similarities are noted between children in blocks 3 and 4. A detailed discussion of the implications of these results is given in Chapter 5.

4.3 Testing of hypotheses associated with the multiple regression design.

The hypotheses considered in this part are presented below in null form for reference purposes:

1. There is no relationship between observed performance on three map design variables:
   * colour in cartographic signs,
   * map generalisation,
   * map lettering,

and performance on these same variables predicted from a combination of competence in cartographic language and map-reasoning level.

2. There is no relationship between observed performance on ten map user variables:
   * age,
   * map-reading ability,
   * home environment,
   * previous experience with maps,
   * understanding the concept of a map,

- drawing ability,
- attitudes to maps,
- nonverbal intelligence,
- verbal intelligence,
- spatial ability,

and performance on these same variables predicted from a combination of competence in cartographic language and map-reasoning level.

3. There is no relationship between observed performance on three map design variables:
    - colour in cartographic signs,
    - map generalisation,
    - map lettering,

and performance on these same variables predicted from a combination of performance in cartographic language and map-reasoning level.

4. There is no relationship between observed performance on eleven map user variables:
    - age,
    - competence in cartographic language,
    - map-reading ability,
    - home environment,
    - previous experience with maps,
    - understanding the concept of a map,
    - drawing ability,
    - attitudes to maps,
    - nonverbal intelligence,
    - verbal intelligence,
    - spatial ability,

and performance on these same variables predicted from a combination of performance in cartographic language and *map-reasoning level.*

These hypotheses are associated with questions 4, 5, 6 and 7 in Chapter 1.

Multiple regression analyses using the NYBMUL program developed by Finn (1972) were used to test these hypotheses. The significance of the observed values of the multiple regression coefficient is determined using the F ratio which is calculated using Kerlinger's formula (as outlined in Chapter 3.53).

The four hypotheses in this segment are concerned with predicting the children's scores on three map design variables (V_1 to V_3) and ten or eleven map user variables (V_4 to V_{13} or V_4 to V_{14}) from:

(a) a combination of the children's scores on map-reasoning and competence in cartographic language or

(b) a combination of the children's scores on map-reasoning and performance in cartographic language.

These analyses will indicate which dependent variables influence children's competence and performance in cartographic language, and their map-reasoning.

Hypothesis 1. *There is no relationship between observed performance on three map design variables:*

- *colour in cartographic signs,*
- *map generalisation,*
- *map lettering,*

and performance of these same variables predicted from a combination of competence in cartographic language and map-reasoning level.

The multiple regression analyses for the three map design variables - V_1(colour in cartographic signs), V_2(map generalisation) and V_3(map lettering) - as predicted from a combination of the children's competence in cartographic language and their map-reasoning level, is presented in Table 42. Table 42 presents the multiple regression coefficient , the F ratio and the p value for each dependent variable.

Table 42 MULTIPLE REGRESSION ANALYSIS OF THREE MAP DESIGN VARIABLES ON COMPETENCE IN CARTOGRAPHIC LANGUAGE AND MAP-REASONING LEVEL.

VARIABLE	MULTIPLE R	F	p
V_1	.45	73.25	0.0001**
V_2	.57	147.24	0.0001**
V_3	.63	200.82	0.0001**

** Significant at 0.0001 level

The results indicate that the multiple regression coefficients for colour, map generalisation and map lettering are highly significant with a p value less then 0.0001. This indicates a strong link between these three map design variables, the children's map-reasoning level and their competence in cartographic language.

Hypothesis 2. There is no relationship between observed performance on ten map user variables:

- age,
- map-reading ability,
- home environment,
- previous experience with maps,
- understanding the concept of a map,
- drawing ability,
- attitudes to maps,
- nonverbal intelligence,
- verbal intelligence,
- spatial ability,

and performance on these same variables predicted from a combination of competence in cartographic language and map-reasoning level.

The multiple regression analyses for the ten map user variables - V_4 (age), V_5 (map-reading ability), V_6 (home environment), V_7 (previous experience with maps), V_8 (understanding the concept of a map), V_9 (drawing ability), V_{10} (attitudes to maps), V_{11} (nonverbal intelligence, V_{12} (verbal intelligence) and V_{13} (spatial ability) - as predicted from a combination of competence in cartographic language and map-reasoning level, is presented in Table 43. Table 43 presents the multiple regression coefficient , the F ratio and the p value for each dependent variable.

Table 43 MULTIPLE REGRESSION ANALYSIS OF TEN MAP USER VARIABLES ON COMPETENCE IN CARTOGRAPHIC LANGUAGE AND MAP-REASONING LEVEL.

VARIABLE	MULTIPLE R	F	p
V_4	.35	40.79	0.0001**
V_5	.61	172.61	0.0001**
V_6	.40	57.23	0.0001**
V_7	.31	29.48	0.0001**
V_8	.46	79.18	0.0001**
V_9	.31	31.52	0.0001**
V_{10}	.04	0.39	0.53
V_{11}	.50	98.41	0.0001**
V_{12}	.55	114.45	0.0001**
V_{13}	.54	107.93	0.0001**

** significant at 0.0001 level

The results of Table 43 indicate that all of the selected map user variables, except for V_{10} (attitudes to maps), are highly significant each with a p value less than 0.0001. The variables possessing the highest multiple regression coefficients and F ratios are V_5 (map-reading ability), V_{11} (non verbal intelligence), V_{12} (verbal intelligence) and V_{13} (spatial ability). V_{10} (attitudes to maps) is the only map user variable associated with the affective domain which is used in this study. Its insignificance in Table 43 reflects the difficulty of directly linking children's feelings with mastery or understanding. Therefore, the children's age, map-reading ability, home environment, previous experience with maps, understanding of the concept of a map, drawing ability, nonverbal intelligence, verbal intelligence and spatial ability influence their competence in cartographic language and their map-reasoning level.

Hypothesis 3. There is no relationship between observed performance on three map design variables:

- colour in cartographic signs ,
- map generalisation ,
- map lettering ,

and performance on these same variables predicted from a combination of performance in cartographic language and map-reasoning level.

The multiple regression analyses for the three map design variables - V_1 (colour in cartographic signs), V_2 (map generalisation) and V_3 (map lettering) - as predicted from a combination of the children's performance in cartographic language and their map-reasoning level is presented in Table 44. It presents the multiple regression coefficient , the F ratio and the p value for each dependent variable.

Table 44 MULTIPLE REGRESSION ANALYSIS OF THREE MAP DESIGN VARIABLES ON PERFORMANCE IN CARTOGRAPHIC LANGUAGE AND MAP-REASONING LEVEL

VARIABLE	MULTIPLE R	F	p
V_1	.15	6.68	0.01*
V_2	.18	9.74	0.002*
V_3	.21	12.90	0.0001**

** significant at 0.0001 level

* significant at 0.05 level

The results of Table 44 indicate that the multiple regression coefficient for map lettering is highly significant with a p value less than 0.0001. They also indicate that the multiple regression coefficients for map generalisation and colour in cartographic signs are significant with p values for each variable less than 0.05. These results mean that there is a significant link between the three selected map design variables - colour in cartographic signs. map generalisation and map lettering - the children's performance in cartographic language and their map-reasoning level.

Hypothesis 4. There is no relationship between observed performance on eleven map user variables:

* age ,
* map-reading ability ,
* home environment ,
* previous experience with maps ,
* understanding of the concept of a map ,

- drawing ability ,
- attitudes to maps ,
- nonverbal intelligence,
- verbal intelligence ,
- competence in cartographic language ,

and performance on these same variables predicted from a combination of performance in cartographic language and map-reasoning level.

The multiple regression analysis for the eleven map user variables - V_4 (age), V_5 (map-reading ability), V_6 (home environment), V_7 (previous experience with maps), V_8 (understanding the concept of a map), V_9 (drawing ability), V_{10} (attitudes to maps), V_{11} (nonverbal intelligence), V_{12} (verbal intelligence), V_{13} (spatial ability) and V_{14} (competence in cartographic language) - as predicted from a combination of the children's performance in cartographic language and their map-reasoning level, is presented in Table 45. This Table presents the multiple regression coefficient , the F ratio and the p value for each dependent variable.

The results indicate that the multiple regression coefficients for V_5 (map-reading ability), V_{12} (verbal intelligence). V_{13} (spatial ability) and V_{14} (competence in cartographic language) are highly significant, each with a p value less than 0.0001. They also indicate that the multiple regression coefficients for V_7 (previous experience with maps), V_8 (understanding of the concept of a map) and V_{11} (non verbal intelligence) are significant each with a p value less than 0.05. These results indicate that there is a significant link between the children's map-reading ability, previous experience

Table 45 MULTIPLE REGRESSION ANALYSIS OF ELEVEN MAP USER VARIABLES ON PERFORMANCE IN CARTOGRAPHIC LANGUAGE AND MAP-REASONING LEVEL

VARIABLE	MULTIPLE R	F	p
V_4	.05	0.57	0.45
V_5	.22	15.23	0.0001**
V_6	.08	1.85	0.18
V_7	.13	4.93	0.02*
V_8	.20	12.62	0.0005*
V_9	.09	2.30	0.13
V_{10}	.02	0.06	0.8
V_{11}	.12	4.46	0.03*
V_{12}	.27	22.25	0.0001**
V_{13}	.25	20.27	0.0001**
V_{14}	.25	19.70	0.0001**

** significant at 0.0001 level

* significant at 0.05 level

with maps, understanding of the concept of a map, non verbal and verbal intelligence, and: (a) their competence in cartographic language; (b) their performance in cartographic language; and (c) their map-reasoning level.

In summary, the children's competence and performance in cartographic language, across the concrete level of map-reasoning, are significantly linked with:

a) three map design variables : colour in cartographic signs, map generalisation and map lettering, and
b) six map user variables : map-reading ability, previous experience with maps, understanding the concept of a map, non verbal and verbal intelligence, and spatial ability.

In addition, the children's age, home environment and drawing ability are linked significantly with their competence in cartographic language and their map-reasoning level. Their competence in cartographic language is linked significantly with their performance in cartographic language and their map-reasoning level. A detailed discussion of the implications of these results is given in Chapter 5.

4.4 Subjective data.

Children's observations and preferences illuminate their thinking. Therefore, in the instruments concerning their understanding of the concept of a map, the use of colour in cartographic signs and map lettering, the children were asked additional subjective questions. These questions consist of choices between alternatives or open-ended preferential questions. The results of these questions are associated with question 8 in Chapter 1.

4.41 Children's verbal definitions of a map.

The children's verbal definitions of a map indicate how children at the concrete map-reasoning level perceive a map. Since they are not able to reason abstractly, the children are probably not able to define a map accurately - at least, not across the four concrete map-reasoning blocks.

Representative verbal definitions of a map for children in each of the four concrete map-reasoning blocks are presented in Appendix 21. A survey of the verbal definitions indicates that children at the concrete level of map-reasoning define a map in one or more of four ways - a picture, a reference for directions, a reference for locating places, or a representation of an area.

Children who see a map as a picture stress that it is a picture of a place or the world:

> "A map is a pitcher of a place." (block 1 child)
>
> "A map is a pitcher of something like a pitcher of the city or the contry." (block 1 child)
>
> "A map is a picture - a something showing roads, houses, rivers, etc." (block 2 child)

These children possess a very narrow understanding of the concept of a map which is reflected in their level of map-reasoning.

Those children who perceive a map as a reference for directions highlight one of the major practical uses for maps - finding one's way around:

> "A map can give you the location of any city or town. If you are looking for a particular street,

you look up the Index. To find it you get a number and a letter." (block 1 child)

"A map is a piece of paper with directions on it that tell you where to go." (block 1 child)

"A map is a street director. It shows you how you get from place to place." (block 2 child)

"A map is a drawing desired to let you find your way around your suburb, town or city. Without a a map you would find difficulty in finding your way around a new area." (block 3 child)

"A map is a piece of paper or book showing how to get around an unknown place. There are ten kinds of maps showing different things ranging from population to vegetation." (block 4 child)

Except for variations in expression, the range of verbal definitions listed above is uniform in content. Children in each of the four concrete map-reasoning blocks perceive this function for maps.

Maps were perceived as a reference for locating places by children in all map-reasoning blocks. This definition of a map highlights its role in depicting the location of objects in an area:

"A map is a piece of paper that shows where a place is or railroads, parks, rivers, islands, courses, schools, town, streets and other things." (block 1 child)

"A map is a piece of paper showing islands, streets, oceans, mountains, rivers, suburbs, countries, etc." (block 2 child)

"A map is a sketch of a country, island or state showing roads, rivers and tourist attractions and public pools, golf courses, outdoor bowls and other sports grounds." (block 3 child)

"A map is a plan of an area showing different heights, places, towns, cities, buildings, bridges and many other things. It also shows places of interest." (block 4 child)

"I think a map is a directory that shows roads, important buildings, rivers, land, islands, countries, towns, cities and a map guides you." (block 4 child)

Children do not limit the range of objects they depict on maps. They include a range of physical and cultural features in their verbal definitions. Children in block 4 indicate greater detail in the range of objects they represent on maps.

The most sophisticated verbal definitions perceive maps as representations of an area, drawn to scale from a plan view. The older children produce a more inclusive definition:

"A map is a photograph or a drawing of a part of the world or a part of the world made up. It shows you where the places, roads, etc, are." (block 1 child)

"A map is an illustration of an area reduced to fit on the paper." (block 2 child)

"A map is a plan from looking above and seeing the shape of land or the top of houses." (block 2 child)

"A map is an area drawn to scale on a piece of paper showing parks, streets, shops, etc." (block 3 child)

"A map is a picture of an area set out on a piece of paper on a much smaller scale. It shows nearly every road and detail; some show houses." (block 3 child)

"A map is a representation of the earth or portion of it on a plane surface." (block 4 child)

"A map is an accurate representation of an area of land that has been scaled down to fit in a small area. Things such as place names, land heights, rainfall and population, are shown by symbols or shading." (block 4 child)

It was not expected that the distribution of the above four definitions of maps would be spread evenly across the four concrete map-reasoning blocks. It was expected that more children in block 1 would associate maps with pictures and that more children in block 4 would associate maps with representations of areas. Table 46 presents the distribution of the four map definitions across the four concrete map-reasoning blocks.

Table 46 DISTRIBUTION OF FOUR VERBAL MAP DEFINITIONS ACROSS FOUR CONCRETE MAP-REASONING BLOCKS

(per cent)

MAP DEFINITION \ BLOCK	1	2	3	4
Map as a picture	11.48	2.04	0.0	0.0
Map as a reference	57.38	46.94	23.15	10.42
Map as a location	24.58	35.71	63.89	55.56
Map as a representation	6.56	15.31	12.96	34.02
TOTAL	100.00	100.00	100.00	100.00

Table 46 indicates that children in block 1 see a map primarily as a reference for finding one's way (much like a street directory) and to a lesser extent as a means of locating places. Children in block 2 see a map as either a reference for finding one's way or as a means of locating places. In block 3, the children see a map primarily as a means of locating places. Children in block 4 see a map as either a representation of an area on a plane surface or as a means of locating places. Therefore, there is a trend across the concrete map reasoning blocks from an emphasis on a map as a referdex through a map as a means of locating places to a map as a representation of an area on a plane surface.

4.42 Map lettering.

The children in the study group were tested on their understanding of cartographic information based on the positioning of names on two maps containing similar cartographic information. Their scores on this test were used in testing the hypotheses concerning questions 3,4,5,6 and 7 in Chapter 1. In addition, the children were asked to state why the map of island X is easier to read than the map of island Y (see Appendix 8). This was to ascertain the children's perceptions on the use of names on maps. Their responses are summarised in Table 47.

The children's responses in Table 47 indicate that their dominant perceptions of the improved readability of the map of island X are the clarity/neatness of the type (from 31.5 per cent in block 3 to 60.3 per cent in block 2) and the even spacing of the type (13.9 per cent in block 4 to 23.3 per cent in block 2). Table 47 also indicates that there is a distinctive pattern in the children's responses from block 1 to block 4. This pattern is characterised by: (a) an increase in the children's response rate (0.84 responses per child in block 1 to 2.4 responses per child in block 4), and (b) a broadening of the range of children's responses across the four blocks (children in block 1 stress clarity/neatness of type (60.3 per cent) and even spacing of type (20.5 per cent); children in block 2 stress clarity/neatness of type (48.9 per cent) and even spacing of type (23.3 per cent), with a lesser emphasis on features intruding through the type (9.3 per cent), smaller type (5.8 per cent) and consistent direction of type (4.7 per cent); children in block 3 stress clarity/neatness of type (31.5 per cent), even spacing of type (23.0 per cent), neater type (15.4 per cent) and features intruding through the type (12.4 per cent), with a lesser emphasis on smaller type (5.4 per cent) and better planned distribution of type (4.6 per cent); and children in block 4 stress clarity/neatness of type (32.2 per cent), features intruding through the type (16.1 per cent), even spacing of type (13.9 per cent) and type variation (10.0 per cent), with a lesser emphasis on consistent direction of type (7.7 per cent), neater type (5.0 per cent), smaller type (5.0 per cent), type presented "the right way up",i.e. it is read without moving/turning the map (4.5 per cent),and proximity of the type to the feature being labelled (3.4. per cent)).

The broadening of the children's responses on the positioning of map type is associated with increased depth in their perception. Children in block 1 perceive

Table 47 CHILDREN'S REASONS FOR THE CLARITY OF MAP LETTERING ON THE MAP OF ISLAND"X" WHEN COMPARED WITH THE MAP OF ISLAND "Y"

MAP REASONING BLOCK	1		2		3		4	
REASONS	NUMBER OF RESPONSES	%	NUMBER OF RESPONSES	%	NUMBER OF RESPONSES	%	NUMBER OF RESPONSES	%
•Clarity/Neatness	38	60.30	42	48.90	41	31.50	58	32.20
•Even Spacing	13	20.50	20	23.30	30	23.00	25	13.90
•Features Intruding Through Type	3	4.80	8	9.30	16	12.40	29	16.10
•Type is "the Right Way Up"	2	3.20	0	0.00	1	0.77	8	4.50
•Type Variation	0	0.00	1	1.14	3	2.31	18	10.00
•Consistent Direction of Type	1	1.60	4	4.70	3	2.31	14	7.70
•Neater Type	0	0.00	1	1.14	20	15.40	9	5.00
•Smaller Type	0	0.00	5	5.80	7	5.40	9	5.00
•Better Planned Distribution of Type	1	1.60	2	2.30	6	4.60	2	1.10
•Proximity of Type to Feature	0	0.00	0	0.00	2	1.54	6	3.40
•Neat Legend	0	0.00	1	1.14	0	0.00	2	1.10
•Accuracy	0	0.00	2	2.30	1	0.77	0	0.00
•More Interesting Map Type	1	1.60	0	0.00	0	0.00	0	0.00
•Others	4	6.40	0	0.00	0	0.00	0	0.00
TOTAL	63	100.00	86	100.02	130	100.00	180	100.00
RESPONSES PER CHILD	0.84		1.15		1.73		2.40	

general characteristics of sensible map typography - clarity/neatness and even spacing. Children in blocks 2 and 3 take greater cognisance of the merging of type and other cartographic signs, as well as the size of the type. In block 4, the children extend these reasons to include type variation, consistent direction of type and proximity of type to the feature being labelled. Therefore, by the time the children are at the highest level of concrete map reasoning, they are perceiving many of the attributes of map typography which Imhof (1962) emphasises in maximising cartographic communication.

4.43 Colour in cartographic signs.

The children's understanding of the use of colour in cartographic signs was determined by their appreciation of cartographic information on coloured and black-and-white orthophoto and topographic maps of Singleton (New South Wales, Australia), which are presented at a scale of 1:25,000. The data from this task were used to test the hypotheses concerning questions 4,5,6 and 7 in Chapter 1.

The children were also asked questions concerning:

(a) their ability to read signs on coloured and black-and-white maps,

(b) the perceived clarity of specific signs on both types of maps,

(c) the ease of reading coloured signs on orthophoto and topographic maps, and

(d) the perceived proximity of signs to their referents.

In the following presentation of data, map A refers to the orthophotomap of Singleton and map B refers to the topographic map of Singleton.

The children were asked to select which of the coloured and black-and-white versions of the orthophotomap and topographic maps are easier to read. The children's reponses are summarised in Table 48.

Table 48 CHILDREN'S PREFERENCES FOR COLOURED OR BLACK-AND-WHITE ORTHOPHOTO AND TOPOGRAPHIC MAPS (per cent)

MAP-REASONING BLOCKS MAP TYPE	1	2	3	4
MAP A:				
COLOURED	85.1	92.5	82.1	83.6
BLACK-AND-WHITE	14.9	7.5	17.9	16.4
MAP B:				
COLOURED	92.5	97.0	92.5	91.1
BLACK-AND-WHITE	7.5	3.0	7.5	8.9

Table 48 indicates that a majority of children in each of the four concrete map-reasoning blocks prefer to read coloured orthophotomaps and topographic maps. Their preference for coloured topographic maps is consistently higher than that for coloured orthophotomaps. Table 48 indicates a uniformity of this preference across the four concrete map reasoning blocks. Children in block 2 express a marginally higher preference for colour in both map types than do children in the other three concrete map-reasoning blocks.

The children were asked to provide reasons for their preferences. Appendix 22 summarises their responses.

For the orthophotomap of Singleton (map A), the children's responses across the blocks vary from superficial statements by children in block 1 through to more detailed, reasoned statements by children in block 4. Also, the children's responses were either positive responses regarding the attraction of one map or negative responses regarding the dislike of one map. Typical positive statements by the children regarding the preference of the coloured orthophotomap include the following:

> "The coloured map is brighter and easier to look at." (block 1 child)
>
> "The coloured map is easier to read because the writing stands out better."(block 1 child)
>
> "It has different colours indicating rivers,roads, railways,etc. while the other one doesn't." (block 2 child)
>
> "I chose this map because you can see the different colours on the land - where the forests are thicker or thinner." (block 3 child)
>
> "Using different colours it is easier to see different parts and places on the map. It is easier to distinguish between the different bits."(block 4 child)
>
> "It is more realistic."(block 4 child)

These comments focus on the realism and ease of reading the information on the coloured orthophotomap.

Typical negative statements about the black-and-white orthophotomap which led to the children's preference of the coloured orthophotomap include the following:

> "Because the black-and-white map has black words which don't show up very well and its hard to read." (block 1 child)
>
> " Because the black-and-white map is all grey and hard to read." (block 2 child)
>
> "Because the black-and-white one is all dark and all

the lines are dark." (block 3 child)

These negative statements concerning the black-and-white orthophotomap are confined to children in blocks 1,2 and 3. They focus on the difficulty of reading black labels on a grey background and the monotony of the grey tones on the map.

The minority of children who prefer the black-and-white orthophotomap do so because they are confused by the colours or because they prefer the evenness of grey tones for extracting cartographic information:

> "I chose the black-and-white one because it is easier to read." (block 1 child)
>
> "Because the colour is sharp in some places and the black-and-white is evenly coloured." (block 2 child)
>
> "Because the colours confuse me."(block 3 child)
>
> "Because the black stands out from the white which makes it clearer. The greens seem to blend in with the other greens." (block 4 child)

The male children in this category may have been in the small minority of males who suffer from colour blindness.

The children's responses regarding the topographic maps of Singleton (map B) are dominated by their positive statements in favour of the use of colour in the cartographic signs. This pattern occurs across the four concrete map-reasoning blocks. These positive statements highlight the children's perception of colour as discriminating between different types of signs, enabling the type to be seen more clearly and making the map easier to read:

> "Because you can see it easier where the roads and rivers are." (block 1 child)

"Because the colour is clearer and you can see the words easier." (block 2 child)

"Because you can find what a place is like by its colour. If it is blue, you know it is water of some kind." (block 3 child)

"Easier to read and clearer to understand the information it is conveying." (block 4 child)

"Because things like rivers, swamps and forests can be contrasted more clearly on the white surface." (block 4 child)

The only notable comments in favour of a black-and-white topographic map are from a minority of children in block 4 who see the grey tones as less confusing than the colours:

"It is less confusing than the colour."

"It is very clear because the black stands out from the white."

Therefore, most children at the concrete level of map reasoning prefer colour on orthophotomaps and topographic maps.

The children were asked whether the signs were easier to read on the coloured orthophotomap or on the coloured topographic map. Their responses are summarised in Table 49.

Table 49 CHILDREN'S PREFERENCE OF COLOUR IN CARTOGRAPHIC SIGNS ON THE SINGLETON ORTHOPHOTOMAP OR TOPOGRAPHIC MAP (per cent)

MAP-REASONING BLOCK MAP TYPE	1	2	3	4
ORTHOPHOTOMAP	38.6	21.7	21.7	17.7
TOPOGRAPHIC MAP	61.4	78.3	78.3	82.3

Table 49 indicates that a majority of children in each of the four concrete map-reasoning blocks prefer the coloured signs on the topographic map of Singleton. It also indicates that the percentage of children preferring the colours in the topographic map signs increases across the blocks from 61.4 per cent in block 1 to 82.3 per cent in block 4.

The children were asked to indicate reasons for their preferences in Table 49. Appendix 23 presents a comprehensive summary of these reasons.

Children in block 1 prefer the colour on the topographic map because the colours are easier to read, the map is not smothered in colour and because it contains more names:

> "Because the colours of the map are easier to read."
>
> "Because it is not full of colour."
>
> "Because it has more names of places."

They are less convincing in their reasons for selecting the coloured orthophotomap. They see it as an easier map to see information:

> "It is easy to look straight at whatever you want."
>
> "Because it is easier to see."

Children in block 2 are more precise in their reasons for preferring the coloured topographic map. They appreciate brighter colours, greater colour variation, the presence of a key of coloured signs and the greater clarity of the colours used on the topographic map:

> "Because the colours are brighter on B, because they go from one extreme to the other."

"It has different colours and a key."

"Because it is much better marked."

A few children prefer the coloured orthophotomap because they see it as being easier to read and, by its photographic origin, closer to real life:

"Because it was easy to read the writing."

"It is a photograph and you can easily tell."

An identical majority of children in map-reasoning blocks 2 and 3 prefer the colour in topographic map signs for similar reasons - clarity of signs, greater variety of signs and brightness of colours in the signs. The only difference is that children in block 3 are more precise in their statements of reasons:

> "Because the colours are brighter and the brighter colours help, e.g. rivers - blue."
>
> "It looks nicer and the colours are clearer and there are more variety of colours."
>
> "Because it is clearer and doesn't have different colours every few centimetres."

Similarly, a small minority prefer map A because its colours are closer to real life:

> "Because map A has the colours for rivers, shrubs, etc."
>
> "Map B uses different colours which stand out against each other while map A used all green."
>
> "Because the colours are definite on map B and each subject, e.g. roads, has a particular colour."
>
> "Because the signs are different and stand out more on white. Map A is all the same colour (different shades)."

The few children in block 4 who prefer colour on map A do so because of its closeness to reality:

> "Because it does not have lines going all over it, you can see every tree and house."

Therefore, most of the children across the four concrete map-reasoning blocks prefer coloured topographic map signs because they are: (a) better discriminated; (b) presented on a white background; and (c) more colourful and appealing. The minority of children who prefer coloured orthophotomap signs invariably do so because they feel that these colours are associated more closely with reality.

The children were asked to indicate which of the coloured maps presented signs in colours closer to real life. Their responses are summarised in Table 50.

Table 50 CHILDREN'S PERCEPTION OF THE LACK OF DISTANCE BETWEEN SIGN AND REFERENT ON COLOURED ORTHOPHOTO AND TOPOGRAPHIC MAPS (per cent)

MAP-REASONING BLOCKS MAP TYPE	1	2	3	4
ORTHOPHOTOMAP	60.3	68.4	61.3	81.3
TOPOGRAPHIC MAP	39.7	31.6	38.7	18.7

Table 50 indicates that a majority of children in each of the four concrete map-reasoning blocks prefer the signs on the orthophotomap. This Table also indicates similar majorities for children in blocks 1,2 and 3 (60 per cent to 70 per cent), but a significantly greater percentage in favour of the orthophotomap in block 4 (81.3 per cent).

The children were asked to provide reasons for their preferences to account for the trend in Table 50. A comprehensive summary of these reasons is provided in Appendix 24.

Children in the four concrete map-reasoning blocks reasoned that the signs on the coloured orthophotomap are closer to real life because the base of the orthophotomap is photographic whereas the topographic map is a graphic representation of an area. Therefore, features such as houses,crops and vegetation, appear more realistic:

"The colours are of the real life."
(block 1 child)

"The homes look real and the road looks real."
(block 1 child)

"Because it is the colour of real life - scrub and crops." (block 2 child)

"Because map B is just like a drawing."(block 2 child)

"Because they are showing houses in their natural colour." (block 3 child)

"Because it is a photo and looks more realistic."
(block 3 child)

"Because it is a photograph of the land and that is the colour of the land." (block 4 child)

"Because it is a real photo and map B is only a sketch,e.g. there are no red roads or towns."
(block 4 child)

Many of the children who prefer topographic map signs as being more realistic are unable to provide reasons for their preference. Most of those who did indicate a reason, prefer topographic map signs on the grounds of conventionality or the blend of colour on the orthophotomap:

"Because it has more lively colours."(block 1 child)

"On map A the colours are dull and everything would not be dull like that." (block 2 child)

"Because the river is blue." (block 3 child)

"Because rivers are usually blue and forests are green, but on map A rivers are brown."(block 4 child)

"I chose map B because on map A there is far too much colour, but if the colours weren't in so many shades I think that I would like map A more."(block 4 child)

Finally, the children were asked questions concerning the identification of road types and the exact location of trees to clarify their perception of colour in cartographic signs.

The question concerning the identification of types of roads was included to ascertain whether the children are aware of the manipulations of colours which may be used in cartographic signs for the purpose of discrimination. Their responses are summarised in Table 51.

Table 51 CHILDREN'S PERCEPTION OF TYPES OF ROADS FROM COLOURED ORTHOPHOTO AND TOPOGRAPHIC MAPS(per cent)

MAP-REASONING BLOCK MAP TYPE	1	2	3	4
ORTHOPHOTOMAP	44.1	29.8	28.3	15.6
TOPOGRAPHIC MAP	55.9	70.2	71.7	84.4

Table 51 indicates that the majority of children in each of the four map-reasoning blocks perceive that the types of roads are discriminated better on the topographic map, i.e. the children indicate that the variation in colour in the cartographic symbols is more discriminating than for the range of cartographic signals. Table 51 also reveals that children in block 1 are divided on this question. These children have not yet developed an understanding of substantive concepts such as road (as outlined in Chapter 4.1). Therefore, they do not appreciate the structure of the symbol set for types of roads.

The children's reasons for their responses reinforce Table 51. These reasons are summarised in Appendix 25. Their reasons include the clarity of the road symbols on the topographic map, the discrimination between types of roads and the use of a legend to name the road types:

> "Because the red lines are thicker."(block 1 child)
>
> "Because in map A the roads are the same colour as the rivers, while map B has different colours which are easier to recognise." (block 2 child)
>
> "I chose this map because the roads are different colours - if its bitumen or a dirt road."
> (block 3 child)
>
> "Because there is a key which tells you what type it is according to the colours of the roads marked in."
> (block 4 child)

The children who prefer the roads marked on the orthophotomap cannot provide convincing reasons for their preference. Their reasons are based on the reality of the road signs on the orthophotomap or personal whim:

> "Because it shows clearly where the roads go and where they end." (block 1 child)
>
> "Because they show more of the shape of the road.
> (block 3 child)
>
> "Because the roads are not just lines."(block 3 child)

"Because it looks more lively." (block 3 child)

Also, the children were asked a question concerning the location of trees to ascertain whether the use of colour and shape of a sign influence the locational accuracy of a sign. The children's responses are summarised in Table 52.

Table 52 CHILDREN'S PERCEPTION OF THE EXACT LOCATION OF TREES ON COLOURED ORTHOPHOTO AND TOPOGRAPHIC MAPS (per cent)

MAP-REASONING BLOCK MAP TYPE	1	2	3	4
ORTHOPHOTOMAP	60.3	57.1	61.0	66.7
TOPOGRAPHIC MAP	39.7	42.9	39.0	33.3

Table 52 indicates that a majority of children in each of the four concrete map-reasoning blocks believe that the signs on the coloured orthophotomap provide a more exact location of the trees on the map. The percentages of children who prefer the coloured orthophotomap are approximately sixty per cent for children in blocks 1,2 and 3, and 66.7 per cent for children in block 4.

The children's reasons for their preferences are similar across the four concrete map-reasoning blocks. Their reasons are summarised in Appendix 26. They stress the photographic base of the orthophotomap:

"Because they look real and they are close together." (block 1 child)

"Because the colour is like the colour of trees (real), same shape." (block 2 child)

"Because the colours show where the trees are." (block 3 child)

"Because it is a photograph, and in map B the trees have just been drawn on in a particular pattern to show the approximate areas where trees are."
(block 4 child)

Finally, the children were asked to nominate features which they observe more clearly on the coloured orthophotomap and the coloured topographic map. The children's responses are summarised in Tables 53 and 54.

Table 53 indicates that the children in all four concrete map-reasoning blocks perceive the following signs more clearly on the coloured orthophotomap: trees, rivers, roads, houses and towns/urban areas. All of the signs, except that representing farmland, are observed consistently across the blocks. For the sign for farmland, there is a steady increase in the frequency of its observation from block 1 through to block 4.

Table 54 indicates that the signs the children perceive more clearly on the coloured topographic map include those representing trees, rivers, roads and towns/urban areas. These signs are observed consistently across the four concrete map-reasoning blocks.

The response rate per child is similar for both maps for children in blocks 1, 2 and 3. It is marginally higher on the topographic map for children in block 4. The children report a preference for the signs representing trees, rivers, roads and towns/urban areas on both maps. However, the children report a higher frequency of response for each of these signs, across the four concrete map-reasoning blocks, on the topographic map. The signs for farmland and houses are perceived more clearly on the orthophotomap.

Table 53 CHILDREN'S PERCEPTION OF FEATURES SEEN MORE CLEARLY ON THE COLOURED ORTHOPHOTOMAP

MAP-REASONING BLOCK FEATURE	1		2		3		4	
	NUMBER	%	NUMBER	%	NUMBER	%	NUMBER	%
Vegetation	17	12.23	24	13.26	30	16.76	24	13.11
River/Lake	37	26.62	44	24.31	44	24.58	42	22.95
Highland/Contour	4	2.88	6	3.31	8	4.47	11	6.01
Swamp	0	0.00	0	0.00	0	0.00	0	0.00
Road	25	17.99	29	16.04	21	11.73	27	14.76
Railway	8	5.76	6	3.31	1	0.56	2	1.09
House	12	8.63	21	11.60	17	9.50	18	9.84
Town/Urban Area	18	12.95	26	14.36	31	17.32	20	10.93
Farmland	11	7.90	19	10.50	19	10.61	33	18.03
Names/Labels	7	5.04	6	3.31	8	4.47	6	3.28
TOTALS	139	100.00	181	100.00	179	100.00	183	100.00
RESPONSES PER CHILD	1.85		2.41		2.39		2.44	

Table 54 CHILDREN'S PERCEPTION OF FEATURES SEEN MORE CLEARLY ON THE COLOURED TOPOGRAPHIC MAP

MAP-REASONING BLOCK FEATURE	1		2		3		4	
	NUMBER	%	NUMBER	%	NUMBER	%	NUMBER	%
Vegetation	24	16.78	27	14.92	31	17.51	39	17.89
River/Lake	44	30.76	58	32.04	53	29.97	61	27.99
Highland/Contour	1	0.70	1	0.56	3	1.69	11	5.05
Swamp	0	0.00	0	0.00	0	0.00	6	2.75
Road	34	23.78	38	20.99	30	16.95	43	19.72
Railway	8	5.59	11	6.08	8	4.52	8	3.67
House	7	4.90	10	5.52	11	6.21	6	2.75
Town/Urban Area	20	13.99	29	16.02	31	17.51	38	17.43
Farmland	2	1.40	7	3.87	9	5.08	4	1.83
Names/Labels	3	2.10	0	0.00	1	0.56	2	0.92
TOTALS	143	100.00	181	100.00	177	100.00	218	100.00
RESPONSES PER CHILD	1.91		2.41		2.36		2.91	

4.44 Summary.

The subjective data indicate that the children's verbal definitions of a map change across the four concrete map-reasoning blocks from: (a) a map as a street directory; to (b) a map as a means of locating places; to (c) a map as a representation of an area on a plane surface. This development is consonant with developmental theories. The children's definition of a map as a street directory is indicative of concrete cognitive development. Their definition of a map as a representation of an area on a plane surface is indicative of a meaningful understanding of an accurate concept of a map.

The concept of cognitive development is also evident in the children's responses to the positioning of map type/lettering. A majority of children in each concrete map-reasoning block stresses the importance of clarity/neatness and even spacing of the type. However, a distinctive developmental pattern is evident across the four concrete map-reasoning blocks concerning the increase in the children's response rate and the broadening in the range of their responses. The variation of map type, the consistent direction of map type and the proximity of type to the feature it is labelling, become more important reasons in the higher map-reasoning blocks.

The children's perception of colour in cartographic signs indicates their definite preference for colour because of its realism and conventionality. This preference is so for both orthophotomaps and topographic maps. The children prefer the coloured topographic map because it contains signs containing crisper colours. They prefer the orthophotomap because of the limited distance between sign and referent. The investigations into the children's competence in cartographic language (see Chapter 4.1) also reveal that the children achieve higher when they are working with the signs on the coloured orthophotomap. Therefore, although the children prefer the more definite colouring of signs on the topographic map, they achieve higher with the more realistic signs on the orthophotomap. This generalisation is valid for children at the concrete level of map-reasoning. It relates to the children's cognitive development in the level of sophistication of the children's perception of colour in cartographic signs. A detailed discussion of the implications of these results is given in Chapter 5.

CHAPTER FIVE SUMMARY, FINDINGS, CONCLUSIONS AND IMPLICATIONS.

5.1 A review of the study.

The study was designed to examine the development of children's competence in cartographic language and their performance in cartographic language as expressed in free-recall sketch maps. It was restricted to children who displayed concrete map-reasoning abilities. The cartographic communication process is the theoretical base behind the study because it enables researchers to make a systematic investigation of the transmission of cartographic information. The roles of the cartographer and the map user are placed in perspective - the cartographer encodes the information and the map user decodes it. This study investigated the role of map users at the concrete level of map-reasoning in the cartographic communication process.

The study considered a variety of factors which could influence the map user in the cartographic communication process. These factors included three map design variables : colour in cartographic signs, map generalisation and map lettering ; and ten map user variables : age, map-reading ability, home environment, previous experience with maps, understanding of the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence and spatial ability.

Cartographic language was seen as the means by which the cartographer communicates with the map user. Maps are the visual expressions of cartographic language. Cartographic language, in this study, has been examined from a semiotic viewpoint. The semiotic viewpoint focuses on: (a) syntactics (the rules relating to the internal structure of the system of signs); (b) semantics (the meaning of signs or the relationship between signs and the concepts they represent); and (c) pragmatics (the relation of the language to the people who use it - the cartographer and map user). This study focused on semantics in its investigation of the children's understanding of a representative range of cartographic signs and on pragmatics in its concern for the factors influencing the map users' map-reasoning, competence and performance in cartographic language.

Cartographic language in this study was defined as the blend of line, point, area and alphanumeric signs which may present qualitative (locational) information or quantitative (measured) information about phenomena in an area. The definition of cartographic language in this study has been broadened to include the standard elements which are invariably located in the margins of maps - title, scale, direction indicator and key/legend.

The signs used on maps were defined further in terms of the degree of distance between sign and referent. Therefore, a continuum of cartographic signs was identified ranging from cartographic signals (at the most realistic end of the continuum) through mimetic or pictorial symbols to abstract symbols.

Children's competence and performance in cartographic language are defined in psycholinguistic terms - competence being the individual's ability to understand language and performance being the individual's ability to use language successfully in a situation. In this study, competence in cartographic language consisted of the processes of identification (knowing the look of signs) and comprehension (knowing the meaning of signs in and out of context, understanding the substantive concepts represented by the signs, and making inferences about the signs). A link between competence and performance was developed on the basis of psycholinguistic research. This link is that an individual's performance may be influenced by his competence plus a range of personal attributes including intelligence, home environment, perception, reading ability and attitudes.

The data were gathered during mid - 1978 in three metropolitan Queensland schools located in the middle and outer western suburbs of Brisbane. The population consisted of 642 children in Years four through nine, aged 8.3 years to 14.8 years. These children were administered the Salomon-Feldman test of map-reasoning as the basis for grouping. They were grouped into four map-reasoning levels. The four map-reasoning levels were placed on a four point scale (as illustrated in Figure 22 in Chapter 3.20). It was established that the range of concrete level map-reasoning was from 2.5 to 3.5 on this scale. On this basis, four blocks were created by dividing the range 2.5 - 3.5 into four equal intervals. 546 of the above children were classified as concrete thinkers in relation to maps. These children were spread evenly across the four blocks. The final group of 300 children (75 children from each block) was determined on the basis of random selection. Therefore, this study was organised on a randomised block design based on children's map-reasoning level, with 75 children in each of four cells.

The instruments used in this study consisted of a range of investigator-designed and standardised instruments. The children's competence in cartographic language was measured using sub-tests of qualitative and quantitative cartographic signs, and standard elements. These sub-tests focused on children's abilities to identify and to comprehend a representative range of cartographic signs and standard elements. The children's performances in cartographic language were measured by their ability to draw a free-recall sketch map of their school area. This map was scored on the basis of Snyder, Feldman and La Rossa's(1975) manual for a Piagetian-based,map-drawing exercise.

The measurement of the range of factors affecting the map user was subdivided into the measurement of a selection of three map design variables : colour in cartographic signs, map generalisation and map lettering ; and ten map user variables : age, map-reading ability, home environment, previous experience with maps, understanding the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence, and spatial ability.

The three tests of map design variables : colour in cartographic signs, map generalisation and map lettering; were investigator-designed instruments concerning the children's perceptions and understanding of three key aspects which the cartographer uses when he creates a map. The test on colour in cartographic signs consisted of:

(a) ten questions on the children's understanding of signs with or without colour,and

(b) fourteen questions concerning their perception of of the value of colour in cartographic signs.

The test of map generalisation aimed to determine:

(a) the children's understanding of information drawn on maps at different scales, and

(b) the influence of the size of map signs on children reading maps.

It consisted of thirty questions divided evenly between a pair of orthophotomaps and a pair of topographic maps. Each pair of maps consisted of a larger scale map and a smaller scale map, about which the children were asked similar questions. The map lettering test was designed to determine how the children understood the placement of names on maps. It consisted of two sets of ten similar questions related to a clear, precise map and a confusing map.

The ten map user variables : age, map-reading ability, home environment, previous experience with maps, understanding the concept of a map,drawing ability, attitudes to maps, non verbal intelligence, verbal intelligence, and spatial ability ; consisted of a mixture of investigator-designed and standardised instruments. Age was based on the chronological age of each child. Map-reading ability was obtained by administering the appropriate level of Test W-1 of the Iowa Tests of Basic Skills(Hieronymus et al.,1971). Home environment was measured as an index derived from an investigator-designed survey based on the 1964 National Survey of Parental Attitudes and Circumstances Related to School and Pupil Characteristics by the Central Advisory Council for Education in England(H.M.S.O.,1967). The index was a summation of the literacy in the home; parental involvement and interest in education; home experiences involving maps; parental occupation; and physical characteristics of the home environment.

The children's previous experiences with maps were measured by an index derived from their responses to twenty-one statements concerning the children's membership of clubs or groups using maps or mapping techniques, personal experiences which could involve the use of maps, and the previous use of maps in formal educational settings.

The children's understanding of the concept of a map was obtained by asking them to define a map, to identify maps from non-maps and to indicate why the selected extracts were maps. The children were scored on the summation of their responses to the above tasks.

Their attitudes to maps were obtained using a semantic differential task based on Petchenik's(1974) five general map characteristics which can be examined attitudinally. The characteristics are: spatial characteristics, texture, light, data quality impressions, and emotional reactions. The children's cumulative score on the twenty items became their score on this task.

The remaining instruments used are standardised measures: the children's drawing ability was measured using Eisner's(1967) fourteen point visual and verbal scale, their nonverbal intelligence was determined by administering the Jenkins Nonverbal Test(A.C.E.R.,1973);the A.C.E.R. Intermediate Test A(1964) measured their verbal intelligence; and the A.C.E.R. Space Test(1978) was used to determine the children's spatial ability.

Three separate designs were used to analyse the data. A univariate analysis of variance was used to determine whether significant differences occurred between the children in the four map reasoning blocks on their scores on competence and performance in cartographic language. Where significant differences occurred, multiple comparisons analysis followed.

A multivariate analysis of variance was used to determine whether significant differences occurred between the four map-reasoning blocks on the three map design variables : colour, map generalisation and map lettering; and on the ten map user variables : age, map-reading ability, home environment, previous experience with maps, understanding the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence and spatial ability. Discriminant functions were reported for the factor of map-reasoning level because the F statistic indicated a significant variation among mean vectors. Univariate analyses were performed on the three map design variables and the ten map user variables, and where significant differences occurred, multiple comparisons analysis followed.

A multiple regression design was included in this study to assist the observation and interpretation of the effects of:

(a) map-reasoning level and competence in cartographic language on each of the three map design variables and ten map user variables mentioned above, and (b) map-reasoning level and performance in cartographic language on each of the three map design variables and eleven map user variables (the ten mentioned above plus the children's competence in cartographic language).

The statistical significance of the multiple regression coefficients was obtained using the F ratio.

An analysis was also made of the children's perceptual responses to the positioning of names on maps, the value of colour in cartographic signs and to their understanding of the definition of a map.

5.2 A summary of the results of the study.

In Chapter 4, the results of the study were presented in four parts: (1) the findings of the hypotheses associated with the children's competence and performance in cartographic language; (2) the findings of the hypothesis associated with factors influencing the children's map-reasoning; (3) the findings of the hypotheses associated the multiple regression analyses; and (4) the descriptive analysis of the children's perceptual responses to the positioning of names on maps, the value of colour in cartographic signs,and to their understanding of the definition of a map. A brief summary of the results reported in these sections is presented here. They are discussed in the following section on conclusions.

1. Findings of the hypotheses associated with the children's competence and performance in cartographic language.

Univariate tests performed with:(a) twenty-one variables of children's competence in cartographic language and (b) children's performance in cartographic language as dependent variables,and map-reasoning as the independent variable, indicated the following results:

A. There were significant differences between the mean performances of children in four concrete map-reasoning blocks for the children's competence in cartographic language. Children in concrete map-reasoning block 4 performed best, and children in concrete map-reasoning block 1 performed worst on all twenty-one map competence variables.

B. There were significant differences between the mean performances of children in the four concrete map-reasoning levels for the children's performance in cartographic language. Children in map-reasoning block 4 performed best, and children in map-reasoning block 1 performed worst in their use of cartographic language on free-recall sketch maps.

2. Findings of the hypothesis associated with factors influencing the children's map-reasoning.

Multivariate and univariate tests performed with three map design variables: colour in cartographic signs, map generalisation and map lettering; and ten map user variables : age, map-reading ability, home environment, previous experience with maps, understanding of the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, verbal intelligence and spatial ability ; as dependent variables ,and map-reasoning as the independent variable, indicated the following results:

C. There were significant differences between the mean performance of children in four concrete map-reasoning levels on two map design variables: map generalisation and map lettering ; and six map user variables : age, map-reading ability, home environment, drawing ability, nonverbal intelligence and verbal intelligence. There were significant differences between children in concrete map-reasoning blocks 1 and 4 on all of the above variables. Children in concrete map-reasoning blocks 1 and 2 were significantly different in their performances on all of the above variables except for map-reading ability, drawing ability and nonverbal intelligence. There were significant differences between children in concrete map-reasoning blocks 2 and 3 on all of the above variables except map-reading ability, home environment and nonverbal intelligence. Children in concrete map-reasoning blocks 3 and 4 were significantly different in their performances only on the variables of age, drawing ability, nonverbal and verbal intelligence. There were significant differences between children in concrete map-reasoning blocks 1 and 3 on all of the above variables except nonverbal intelligence.

3. Findings of the hypotheses associated with the multiple regression analyses.

Multiple regression coefficients were calculated to aid interpretation of the effects of the children's map-reasoning level and their competence/performance in cartographic language on each of three map design variables : colour in cartographic signs, map generalisation and map lettering ; and on each of the ten map user variables(eleven for performance in cartographic language): age, map-reading ability, home environment, previous experience with maps, understanding of the concept of a map, drawing ability, attitudes to maps, nonverbal intelligence, and spatial ability (plus competence in cartographic language when related to performance). The significance of each multiple regression coefficient was calculated and indicated the following results:

D. There was a significant relationship between children's observed performance on three map design variables : colour in cartographic signs, map generalisation and map lettering ; and their performance of these same variables predicted from a combination of competence in cartographic language and map-reasoning level. The high significance of the multiple regression coefficients for the three variables indicates a strong positive link between colour in cartographic signs, map generalisation, map lettering, children's competence in cartographic language and their map-reasoning level.

E. There was a significant relationship between children's observed performance on nine map user variables : age, map-reading ability, home environment, previous experience with maps, understanding the concept of a map, drawing ability, nonverbal intelligence, verbal intelligence and spatial ability; and performance on these same variables predicted from a combination of the children's competence in cartographic language and their map-reasoning level. There was not a significant relationship between children's attitudes to maps, their performance in cartographic language and their map-reasoning level. The high significance of the multiple regression coefficients for the above nine map user variables indicates a strong positive link between these map user attributes, the children's competence in cartographic language and their map-reasoning level.

F. There is a significant relationship between children's observed performance on three map design variables : colour in cartographic signs, map generalisation and map lettering ; and their performance on these variables predicted from a combination of their performance in cartographic language and their map-reasoning level. The multiple regression coefficient for map lettering was highly significant, whilst the coefficients for colour and map generalisation were significant. These results indicate that there is a significant positive link between the three map design variables : colour in cartographic signs, map generalisation and map lettering, the children's performance in cartographic language and their map-reasoning level.

G. There is a significant relationship between children's observed performance on seven map user variables : map-reading ability, previous experience with maps, understanding of the concept of a map, nonverbal intelligence, verbal intelligence, spatial ability and competence in cartographic language ; and performance on these same variables predicted from a combination of the children's performance in cartographic language and their map-reasoning level. The multiple regression coefficients for map-reading ability, verbal intelligence, spatial ability and competence in cartographic language were highly significant, whilst the coefficients for previous experience with maps, understanding the concept of a map and nonverbal intelligence were significant. The multiple regression coefficients for age, home environment, drawing ability and attitudes to maps were not significant as predicted from a combination of the children's performance in cartographic language and their map-reasoning level. The results indicate that there is an important positive link between the seven significant map user variables, the children's performance in cartographic language and their map-reasoning level.

4. Subjective data on the verbal definition of a map, the positioning of map letters and the use of colour in cartographic signs.

H. For children at a concrete map-reasoning level, there is an identifiable pattern in their verbal definitions of a map from: (a) a map as a reference at the lowest level; to (b) a map as a location; to (c) a map as representation at the highest level of concrete map reasoning.

I. For children at a concrete map-reasoning level, there is an identifiable pattern in their reasoning on the positioning of map letters. This pattern consists of an emphasis on clarity and even spacing of type for all children, as well as a broadening of the range of responses towards the higher levels of concrete map-reasoning.

J. In terms of their perception of colour in cartographic signs, children at the concrete map-reasoning level indicated a definite preference for colour because of its realism and conventionality on orthophotomaps and topographic maps. Although the children preferred the more definite coloured signs on the topographic map, they were more competent with the more realistic signs on the orthophotomap.

5.3 Conclusions and discussion.

The conclusions are based on the results of this study and are presented initially under separate headings and then synthesised towards the end of this section.

5.31 Children's verbal definitions of a map.

1. Only children in the highest concrete map-reasoning block(mean age 13.12 years) can make accurate verbal definitions of a map.

The majority of the children in the study group did not define a map accurately even in concrete map-reasoning block 4. More of the children in concrete map-reasoning block 1 defined a map as a picture of an area rather than as a representation of that area. However, most of the younger children in concrete map-reasoning blocks 1 and 2 (mean ages 8.95 and 10.12 years respectively) defined a map as a reference for finding one's way. Children in concrete map-reasoning block 3 (mean age 11.51 years) have developed their definition of a map to emphasise the function of a map to locate places and phenomena. Most of the children in concrete map-reasoning block 4 (mean age 13.12 years) saw the function of a map to locate places and phenomena, although more than one-third of the children at this level understood the accurate function of a map to represent the phenomena in an area on a plane surface. Therefore, children at a concrete map-reasoning level cannot define a map accurately, even though a noticeable development in their definitions occurred across the concrete map-reasoning level. This sequence of development in children's verbal definitions of a map is:

(a) a map as a picture,

(b) a map as a reference for finding one's way,

(c) a map as a location of places or phenomena, and

(d) a map as representation of an area on a plane surface.

5.32 Factors affecting children's map-reasoning level.

2. The map-reasoning level of children at the concrete level of thinking is influenced by a number of map design and map user factors.

In this study which investigated the influence of three map design factors and ten map user factors on children's map-reasoning, eight factors were found to be significant influences across the four concrete map-reasoning blocks. These were two map design factors : map generalisation and map lettering ; and six map user factors : age, map-reading ability, home environment, drawing ability, non-verbal intelligence and verbal intelligence. The children's previous experience with maps, understanding the concept of a map, attitudes to maps, spatial ability, and understanding of colour in cartographic signs, were not significant.

The statistical analyses of the mean differences among the four concrete map-reasoning blocks on a multivariate level indicated two directions of discrimination. The first direction was characterised by the factors : age, map lettering, drawing ability and verbal intelligence ; which displayed increasing group mean scores from block 1 through to block 4 . The factor of age proved to be the most powerful influence on children's map-reasoning of the factors used in this study. The second direction of discrimination which was characterised by the factors of map-reading ability, map generalisation, home environment, and nonverbal intelligence, contained less orderly arrangements of group mean scores, but contained the second-most influential factor of children's map-reasoning(map-reading ability).

Univariate analyses of these influential factors indicated a general developmental sequence across the four concrete map-reasoning blocks from block 1 through to block 4, although similarities were noted between blocks 3 and 4. The exceptions to this sequence are home environment and nonverbal intelligence. Since home environment was scored on an index derived from a subjective survey, the lack of significant differences among the four concrete map-reasoning blocks was not unexpected. The lack of many significant differences regarding the children's nonverbal intelligence is less easily explained, and may be related to the pictorial nature of the test items.

The statistical analyses in this study indicated that children's map-reasoning at the concrete level is influenced significantly by their age, map-reading ability, verbal and nonverbal intelligence, drawing ability, and home environment, as well as their understanding of map generalisation and the positioning of names on maps.

5.33 Children's development of competence in cartographic language.

3. Development of children's competence in cartographic language has occurred at the concrete map-reasoning level.

Children's competence in cartographic language was measured in relation to their ability to identify and to comprehend line, point and area signs of both a qualitative and a quantitative nature, as well as signs representing standard elements on maps.

The children's development of competence in cartographic language across the four concrete map-reasoning blocks was highly significant. The univariate analyses indicated this was so for all variables. Therefore, the competence of children in cartographic language in each one of the four concrete map-reasoning blocks was significantly different from the competence of children in each of the other three blocks.

This pattern varied when the significance of the differences among the group means of the above components of competence in cartographic language was investigated. The children's identification of cartographic signs generally indicated that their scores in concrete map-reasoning blocks 1 and 2 were homogeneous and significantly different from those of children in blocks 3 and 4 whose scores were also homogeneous. The main exceptions were:

(a) qualitative line signs and quantitative area signs, where children's scores in blocks 2, 3 and 4 were homogeneous and significantly different from those of children in block 1, and

(b) quantitative line signs and qualitative area signs where children's scores in blocks 3 and 4 were significantly different.

These variations in children's identification of different types of cartographic signs reflect the nature of the identification process - knowing the look of the signs. Except for quantitative line signs and qualitative area signs, children in concrete map-reasoning block 3 were competent in identifying cartographic signs.

The pattern varied differently for the comprehension of cartographic signs. Although the children's total comprehension scores on each concrete map-reasoning block were significantly different from for each of the three other blocks, their total scores on the comprehension of quantitative and qualitative signs indicated that the scores for children in concrete map-reasoning blocks 1 and 2 (mean ages 8.95 years and 10.12 years respectively) were homogeneous and significantly different from those of children in blocks 3 and 4. More specifically:

a) children's comprehension scores for the standard elements, quantitative point signs and qualitative area signs indicated that the group mean scores for each concrete map-reasoning were significantly different from those of the three other blocks, and

b) children's comprehension scores for qualitative line signs, quantitative line signs, qualitative point signs and quantitative area signs indicated that children's scores in concrete map-reasoning blocks 1 and 2 were homogeneous and significantly different from those of children in blocks 3 and 4.

Therefore, the children's comprehension of cartographic signs is a better indicator of their competence in cartographic language than their identification of cartographic signs.

The children's mean score for identifying cartographic signs was consistently higher than their mean scores for comprehending cartographic signs for each of the four concrete map-reasoning levels. This conclusion indicated that children at the concrete map-reasoning level become competent in identifying cartographic signs at an earlier age than for comprehending cartographic signs.

5.34 Factors influencing children's competence in cartographic language.

4. The competence in cartographic language for children at the concrete level of map-reasoning is influenced by a number of map design and map user factors.

This study investigated the influence of three map design factors and ten map user factors on children's competence in cartographic language for children grouped according to four concrete map-reasoning blocks. Twelve of these factors were found to be highly significant. They were the three map design factors : colour, map generalisation and map lettering ; and nine map user factors : age, map-reading ability, home environment, previous experience with maps, understanding of the concept of a map, drawing ability, nonverbal intelligence ,verbal intelligence and spatial ability. The children's attitudes to maps was not significant.

The multiple regression analyses supported the above conclusion, since all of the significant multiple regression coefficients were highly significant. They indicated the greatest influences on children's competence in cartographic language were: map lettering, map-reading ability, map generalisation, verbal intelligence, spatial ability and nonverbal intelligence, a blend of map design and map user factors.

The children's reasons for the positioning of names on maps were indicative of their development in map-reasoning across the concrete-thinking level. Whereas over eighty per cent of children in concrete map-reasoning block 1 highlighted clarity/neatness and even spacing of map type, only 46.1 per cent of the children in concrete map-reasoning block 4 did so. These older children indicated greater depth of perception by commenting on type variation, consistent direction of type, and the minimising of the clash of names and signs.

The children's preference of colour in cartographic signs provided limited evidence of children's development in cartographic language. Their preference for colour was overwhelming for all concrete map-reasoning blocks. There was, however, an increasing preference for the coloured topographic map over the coloured orthophotomap across the four concrete map-reasoning blocks. According to the children, this was because the colours on the topographic map were conventional, and better discriminated, although their signs were more distant from their referents.

Only one factor in this study was associated with the affective domain. This factor is children's attitude's to maps. Its insignificance reflects the difficulty of linking children's feelings with mastery or understanding.

5.35 Children's development of performance in cartographic language.

5. Development of children's performance in cartographic language has occurred at the concrete level of map-reasoning.

The development of children's performance in cartographic language is characterised by increased distance between sign and referent. As the children develop competence in using cartographic language, the signs they use on maps become increasingly abstract rather than pictorial. These abstract symbols are decoded in a legend.

5.36 Factors influencing children's performance in cartographic language.

6. The performance in cartographic language for children at the concrete level of map-reasoning is influenced by a number of map design and map user factors.

This study investigated the influence of three map design factors and eleven map user factors on children's performance in cartographic language for children grouped according to four concrete map-reasoning blocks. Ten factors were found to be significant highly significant. They were the three map design factors : colour in cartographic signs, map generalisation and map lettering ; and seven map user factors : map-reading ability, previous experience with maps, understanding the concept of a map, nonverbal and verbal intelligence, spatial ability and competence in cartographic language. Children's age, home environment, drawing ability and attitudes to maps, were not found to be significant.

The multiple regression analyses supported the above conclusion, since the highly significant multiple regression coefficients were map lettering, map-reading ability, verbal intelligence, spatial ability and competence in cartographic language, whilst colour, map generalisation, previous experience with maps, understanding the concept of a map and verbal intelligence, revealed significant coefficients. This conclusion reinforces the psycholinguistic view that performance in language consists of competence plus a range of individual characteristics.

Of the factors which were not significant, age is notable since it has been found to be very influential on map-reasoning level and competence in cartographic language. Since age is closely linked to Piagetian theories of cognitive development, this conclusion runs counter to Piagetian theory. Since children's drawing ability was not significant to their performance in cartographic language, it may be concluded that drawing signs on maps is not a similar operation to drawings of people or places. Also, the subjective element in children's attitudes to maps cannot be used to predict children's performance in cartographic language.

5.37 Synthesis of conclusions.

A synthesis of the conclusions reported in the above parts of this section is presented in Figure 32 (page 349) and Table 55 (page 350). This synthesis reveals that for children at the concrete map-reasoning level:

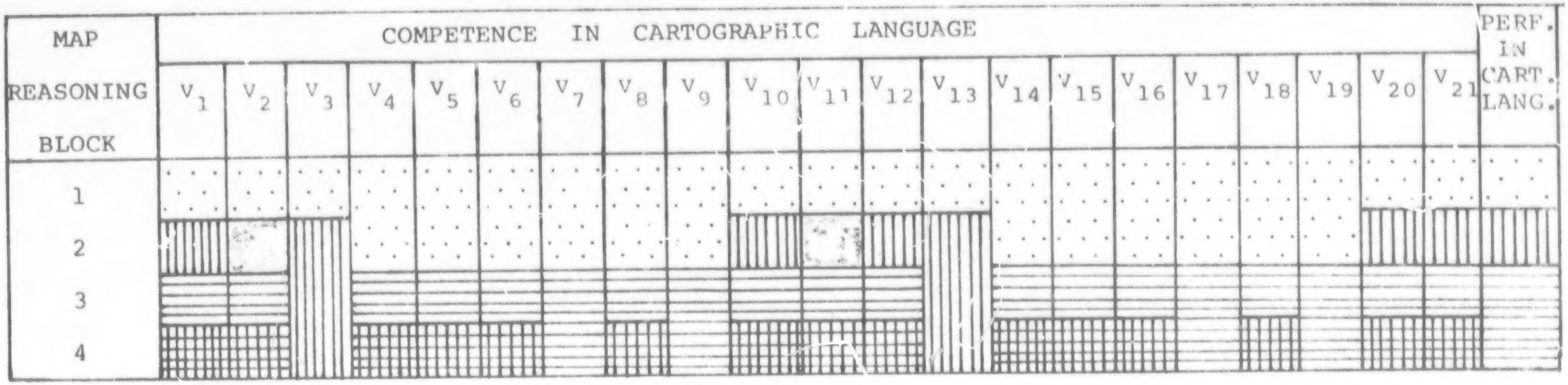
1. There was a definite development in their competence in cartographic language from the younger children (8 + years) through to the older children (14 + years). This development was more evident in their comprehension of cartographic signs. than in their identification of such signs. This development was so for the comprehension of both qualitative and quantitative line, point and area signs, and for the standard elements. The children's identification of cartographic signs lacked substantial evidence of development except for the standard elements, quantitative line signs and

qualitative area signs because competence was acquired at an earlier age by the children.

2. There was a definite development in their performance in cartographic language from the younger children (8 + years) through to the older children (14 + years). Unlike the children's development of competence in cartographic language, their performance in cartographic language revealed limited development at the upper end of the concrete map-reasoning level. This development was reflected in the use of cartographic signals and pictorial/mimetic symbols by children at the lower end of the concrete map-reasoning level and by the use of more arbitrary, abstract symbols at the upper end of the concrete map-reasoning level.

3. There was a definite development in the children's definition of a map across the concrete map reasoning level from a map as a picture and a reference to find one's way, to a map as a location of places, and as a representation of an area.

4. A number of map design and map user variables were found to influence the map-reasoning level of concrete thinkers, and their competence and performance in cartographic language. Of the three selected map design factors, map generalisation and map lettering were significant influences on map-reasoning, competence and performance in cartographic language. The third map design factor - colour in cartographic signs - influenced both competence and performance.


MAP REASONING BLOCK
COMPETENCE IN CARTOGRAPHIC LANGUAGE
PERF. IN CART. LANG.
V_1
V_2
V_3
V_4
V_5
V_6
V_7
V_8
V_9
V_{10}
V_{11}
V_{12}
V_{13}
V_{14}
V_{15}
V_{16}
V_{17}
V_{18}
V_{19}
V_{20}
V_{21}
1
2
3
4

Homogeneous Groups=Blocks which are significantly different from other blocks.

▭ = Divisions between homogeneous groups. ⋯ =Blocks homogeneous with Block 1

▥ = Blocks homogeneous with Block 2. ▤ = Blocks homogeneous with Block 3.

▦ = Blocks homogeneous with Block 4. ▒ = Transition Area(overlap between homogeneous groups).

V_1=Identif. of Standard Elements;V_2=Comprehension of Standard Elements;V_3= Identif. of Qual.Line Signs; V_4=Comp. of Qual. Line Signs;V_5=Identif. of Quant. Line Signs;V_6=Comp. of Quant. Line Signs;V_7= Identif. of Qual. Point Signs;V_8= Comp. of Qual. Point Signs;V_9= Identif. of Quant. Point Signs; V_{10}= Comp. of Quant. Point Signs;V_{11}= Identif. of Qual. Area Signs;V_{12}= Comp. of Qual. Area Signs; V_{13}= Identif. of Quant. Area Signs;V_{14}= Comp.of Quant. Area Signs;V_{15}= Total Identif. of Qual. Signs;V_{16}= Total Comp. of Qual. Signs;V_{17}= Total Identif. of Quant. Signs;V_{18}= Total Comp. of Quant. Signs;V_{19}= Total Identif. of Signs;V_{20}= Total Comp. of Signs;V_{21}= Grand Total Competence Score.

Fig. 32 SUMMARY OF MULTIPLE CLASSIFICATION DIFFERENCES AMONG MAP-REASONING BLOCKS SHOWN BY SHADING FOR SIGNIFICANT VARIABLES IN CHILDREN'S COMPETENCE AND PERFORMANCE IN CARTOGRAPHIC LANGUAGE

Table 55 SUMMARY OF FACTORS INFLUENCING CHILDREN'S COMPETENCE AND PERFORMANCE IN CARTOGRAPHIC LANGUAGE, AND MAP-REASONING LEVEL

VARIABLE	COMPETENCE p value	PERFORMANCE p value	MAP REASONING p value
Map Design			
V_1	0.0001**	0.01*	0.1
V_2	0.0001**	0.002*	0.0001**
V_3	0.0001**	0.0001**	0.01*
Map User			
V_4	0.0001**	0.45	0.0001**
V_5	0.0001**	0.0001**	0.0001**
V_6	0.0001**	0.18	0.01*
V_7	0.0001**	0.02*	0.64
V_8	0.0001**	0.0005*	0.5
V_9	0.0001**	0.13	0.002*
V_{10}	0.53	0.8	0.15
V_{11}	0.0001**	0.03*	0.0001**
V_{12}	0.0001**	0.0001**	0.0001**
V_{13}	0.0001**	0.0001**	0.16
V_{14}	-	0.0001**	-

** significant at 0.0001 level

V_1 - Colour in cart. signs
V_2 - map generalisation
V_3 - map lettering
V_4 - age
V_5 - map-reading ability
V_6 - home environment
V_7 - previous experience with maps
V_8 - understanding of the concept of a map
V_9 - drawing ability
V_{10} - attitudes to maps

* significant at 0.05 level

V_{11} - nonverbal intelligence
V_{12} - verbal intelligence
V_{13} - spatial ability
V_{14} - competence in cartographic language

Map-reading ability, nonverbal intelligence and verbal intelligence, were the factors which influenced map-reasoning level, and competence and performance in cartographic language. Age, home environment and drawing ability, influenced the concrete map-reasoning level and competence in cartographic language. Previous experience with maps, understanding the concept of a map and spatial ability, influenced the children's competence and performance in cartographic language. Also, the children's competence in cartographic language influenced their performance in cartographic language.

5.4 Limitations of the study.

Several limitations of this study may be mentioned before the implications are discussed. The first limitation relates to the sample of children used in the study. These children lived in suburbs which contained predominantly middle and upper socio-economic families, with a minority of lower socic-economic families. A truly representative socio-economic sample would have included a selection of children who lived in the old inner suburbs. Further, the sample considered only children from urban environments from one city in Australia - Brisbane. As indicated in Chapter 3, the children in the actual sample were randomly selected from within each of the four concrete map-reasoning blocks, until seventy-five children were selected in each block. Since more than eighty-five per cent of

Australians live in urban areas, it is difficult to estimate the effect of this limitation on the statistical analyses performed.

Since the data-gathering period was approximately five weeks and since the test instruments were administered randomly, there was ample opportunity for children who had taken a test or survey to discuss it with others in their school who had not taken the test or survey. The reason for raising this limitation is that the investigator noted the enthusiasm which the children showed towards the experience. The investigator was approached by children who were not in the sample, but wanted to be , because children reported that it was a pleasant experience. Teachers indicated that the test experiences aroused the curiosity of others. Therefore, it was apparent that children did talk to others in the study group who had not taken a particular test. The amount of relevant information that was passed on is difficult to ascertain. Since the number of items in most tests was large, this limitation was assumed to be minimal.

Three-quarters of the questions associated with comprehension of cartographic signs were objective test items of the multiple-choice variety. The possibility of children guessing the correct answer is relevant here. Since there were a large number of comprehension questions in the three sub-tests on children's competence in cartographic language, the effect of the children guessing the correct response to multiple-choice questions was judged as minimal.

A limitation of the verbal and nonverbal intelligence tests was the necessity to extrapolate IQ ranges above and below the norms provided in the relevant manuals. For both tests the original norms were calculated for ages 10.0 years through 14.0 years. Since the extrapolation was merely a computational extension of the existing norms, it was viewed as adequate for the children's scores in this study.

Because this study extended over five weeks, it was impossible to control day-to-day variations which could have differential effects on the children. The problem of children's absenteeism was overcome by eliminating from the final study all children who were absent for one or more tasks. However, no allowance was made for weather variation, the individual children's emotional states, or the time of the school day when the tasks were administered.

This study is concerned with the children's development of competence and performance in cartographic language. The best evidence of such development is obtained from a longitudinal study of a range of children through their childhood and adolescent years. The time span of the study did not permit such an investigation.

Finally, no allowance was made for teaching styles relating to the children's use of maps in the classroom. Indirectly, this was accommodated in the final part of the survey of the children's previous experience with maps. This did not allow for the varying degrees of teacher direction of learning in the classroom. Any implications which are drawn have been done so with the above limitations in mind.

5.5 Implications from the study.

This study provides several implications for research, for curriculum development and for classroom teaching. These three aspects will be reported separately along with appropriate recommendations.

5.51 Implications for research.

Previous research performed largely by developmental psychologists such as Piaget and Inhelder(1956), Cassirer(1957) and Werner(1957), has provided considerable knowledge about children's understanding of space. Developmental psychologists provide theoretical bases for understanding aspects of spatial development in children. The conclusions drawn from this study imply, however, that research into cartographic education, if it is to provide the appropriate kind of guidance, must be designed to investigate a greater range of spatial concepts associated with maps and must investigate how these concepts relate to the cartographic communication process.

This study demonstrates that a systematic approach is necessary in any investigation of understanding of the processes of cartographic communication. Such a holistic approach focuses on the key communicators in the process (the cartographer and the map user), the medium of communication(the map), and the mode of communication(cartographic language). It implies that both cartographer and map user must possess a competence in cartographic language before they can communicate successfully.

The study also implies that the semiotic view of cartographic language which focuses on: (a) the rules surrounding the organisation of cartographic signs (syntactics); (b) the relationships between signs and their referents (semantics); and (c) the factors which influence the key participants in the cartographic communication process (pragmatics) is a viable approach to cartographic language. Consideration of the semiotic approach to cartographic language implies a more general consideration of the cartographic communication process rather than specific consideration of map users' perception of a type of cartographic sign.

From the aspect of semantics, the results indicate that children at the concrete map-reasoning level do not identify and comprehend all types of cartographic signs equally. There is a definite development in their ability to identify standard elements and to a lesser extent quantitative line signs and qualitative area signs. Also, there is little development in the children's ability to identify qualitative line signs and quantitative area signs. However, their ability to comprehend all forms of cartographic signs indicates a definite progression in development across the concrete map-reasoning level.

This concern for semantics in the development of cartographic language produced results which imply the importance of the distance between cartographic sign and its referent. The children in the study, via their responses and their expressed perceptions, found the cartographic signals on the coloured orthophotomap easier to understand than the abstract symbols on the coloured topographic map. As the children progressed across the concrete map-reasoning level, they became more able to understand the abitrary, abstract symbols typified on a topographic map. A similar pattern was evident in the children's performance in cartographic language in their free-recall sketch maps; the younger, more concrete-thinking children presented a mixture of cartographic signals (e.g. duplication of the rooflines of buildings) and pictorial symbols whilst the older, less concrete-oriented children presented a mixture of pictorial and abstract symbols.

The results of the investigations into the pragmatics of cartographic communication,which focused on the variety of influences on the map user,imply that the range of influences on him is complex. This is indicated by the fact that map design factors including colour in cartographic signs, map generalisation and map lettering; map user factors including verbal and nonverbal intelligence, age, drawing ability, map-reading ability and spatial ability; and environmental factors such as home environment, are positive influences on the children's map-reasoning, competence and/or performance in cartographic language. The results of these studies in pragmatics indicate some of the sources of interference to the cartographic communication process from the map user's viewpoint. The selection of factors for the studies in pragmatics implies that the map user cannot be isolated from the cartographer in any study which subscribes to the cartographic communication process. In this study, three map design variables - colour in cartographic signs, map generalisation and map lettering,were included as influences of the cartographer on the map user.

The conclusions drawn from this study imply that any research which uses a variety of psychophysical investigations such as the children's perception of colour in cartographic signs, their perceptions on the positioning of map lettering, their identification and comprehension of cartographic signs and their understanding of the concept of a map, is a more realistic type of investigation with regard to cartographic communication than systematic investigations of the elements of a map. For example, part of this study involved an investigation of the children's views on the positioning of type on a map, rather than an investigation into the different type-styles used on maps.

When children draw free-recall sketch maps, they need to consider the arrangement of the phenomena, the appropriate proportion in the area represented and the orthogonal viewpoint, as well as the language used to encode cartographic information. Although this study indicates that it is valid to investigate children's performance in cartographic language via their drawing free-recall sketch maps, it also implies, as do Beck and Wood (1976), that if some of the above variables were eliminated, a more accurate measure of children's performance in cartographic language could be achieved.

Therefore, the following recommendations for further research based on the conclusions and observations of this study, are directed at improving the understanding by cartographic educators of children's thinking in cartographic language. The following recommendations are not presented in any order of importance.

1. Longitudinal studies should be carried out on a select group of children to chart their development of competence and performance in cartographic language throughout their years of formal education.

Such an investigation would be important for it would indicate any sequence of development in the children's development of competence and performance in cartographic language. Since this study concluded that a variety of map user characteristics influenced concrete map-reasoning children's competence and performance in cartographic language, it is recommended that the sample of children used in the longitudinal studies should come from a range of socio-economic backgrounds, live in different environments and have experienced different ranges of cartographic-enriching experiences and different teaching styles.

2. A study should be undertaken to investigate the development of competence and performance in cartographic language for children at all levels of map-reasoning.

The present study indicates that development occurs across the concrete level of map-reasoning. Even though it was concerned with children aged 8 + years through 14 + years, it does not provide a full picture of the developmental sequence as cognitive development occurs. Such a study may be of a longitudinal nature extending over at least a decade or it may consist of identifying a suitable representative sample of children at all map-reasoning levels and determining their competence and performance in cartographic language.

3. Further studies using the semiotic approach should be undertaken to clarify aspects of semantics and pragmatics of this approach to cartographic communication.

The present study is an exploratory investigation using some aspects of the semiotic approach to investigate cartographic language. The investigator concluded that the semiotic approach, which focuses on syntactics, semantics and pragmatics, is helpful for investigating aspects of the cartographic communication process.

In relation to semantics, further consideration needs to be given to the continuum of signals and symbols to refine the key components of this continuum. For pragmatics, further consideration needs to be given to the range of factors influencing the map user. In this study,the map design factors of colour, map generalisation and map lettering, and the map user factors of age, map-reading ability, verbal and nonverbal intelligence, drawing ability, spatial ability, understanding the concept of a map, home environment and previous experience with maps, proved influential. However, the factor of children's attitudes to maps was not influential. Further studies in pragmatics should seek to confirm that the above factors are influential and to investigate new factors, e.g. the teaching styles by which cartographic instruction is given and the children's conventional reading ability.

4. Investigations should be undertaken to establish whether the concepts of identification and comprehension in relation to competence in cartographic language can be refined.

The concepts of identification and comprehension were developed in this present study to clarify the concept of competence in cartographic language. It may be possible to formalise a hierarchy of cartographic signs associated with the processes of identification and comprehension.

5. The investigation of children's performance should be extended to consider performance in cartographic language by other means than free-recall sketch maps.

This may be achieved by restricting the influence of the concepts of arrangement, proportion and orthogonal view. It may be possible then to analyse how children encode a range of line, point and area signs.

6. Further studies into the link between children's competence and performance in cartographic language are essential.

In this study, research by psycholinguists provided the theoretical base for this link by concluding that children's performance in language is determined by their competence in the language plus a range of individual characteristics. The conclusions of this study supported that view. However, further detailed investigations are needed to confirm this link between competence and performance or to suggest new orientations. Future considerations need to consider reasons for this link as well as to describe the link.

7. There is a need to extend the research into the nature of cartographic language to include as wide a range of elements as possible.

The definition of cartographic language used in this study was derived from a psychophysical viewpoint It consists of a range of line, point and area signs presented in qualitative and quantitative forms, alphanumeric signs and standard elements (e.g. scale and direction indicator). Children consider maps as wholes. Therefore, consideration should be given to embracing all of the language components under a single definition.

8. Investigations should be undertaken to determine children's competence in as wide a range of cartographic signs as possible.

This study investigated a representative range of cartographic signs and found that children at similar levels of map-reasoning did not respond equally to each type of cartographic sign. Therefore, it is recommended that a wider range of each type of cartographic sign be investigated for children's competence or the lack of it. These investigations should include children of all map-reasoning levels. In addition, these studies should cover the accepted range of cartographic signs rather than focus on individual signs. This will enable statements of greater generality to be made concerning children's competence in cartographic language.

9. There is a definite need for researchers to develop some standard measures of cartographic language reasoning which may be applied to children's cognitive development.

The scale which Snyder, Feldman and La Rossa (1975) developed for measuring children's performance in cartographic language in free-recall sketch maps is an initial attempt. Further detailed research is necessary to account for the range of cartographic signs as well as the continuum of these signs from signals through pictorial symbols to abstract symbols. If the developmental approach is followed, then it may be possible to devise a comprehensive sequence or scale of cartographic language reasoning.

10. Finally, it is recommended that the research be instigated to examine whether atlases commonly used in primary and secondary schools encourage or hinder the development of cartographic language.

Atlases which do not incorporate valid principles concerning the children's development of competence and performance in cartographic language should not be used in formal education settings. The work of researchers such as Sandford (1972) and Bartz (1965-1967; 1969-1970) should be extended through major research projects.

5.52 Implications for curriculum development.

Curriculum developers in the social sciences usually include statements concerning the use of maps in the documents they prepare for teachers of children in primary and secondary schools. It is not the purpose of this study to investigate how particular statements on maps have come to be included in particular curriculums. Rather it is the purpose of this study to provide several implications from the conclusions of the study to assist future curriculum development in the primary and secondary social sciences.

It has been argued in the theory behind this study that cartographic language is an important component of graphic communication which is one of the four basic modes of communication, along with literacy, numeracy and articulacy. Therefore, it is implied that graphic communication should form an integral part in any social sciences curriculum. Statements on mapping are included in most.

The conclusions of this study reveal that for children at a concrete map-reasoning level there is evidence of developments in their competence and performance in cartographic language. Since the mean ages of the groups of children in this study ranged from 8.9 years through to 13.12 years, it is implied that development in cartographic language occurs across the primary and secondary school levels. The implication for curriculum developers is that children are developing competence and performance in cartographic language well into their secondary years. Therefore, curriculum statements concerning mapping should include specific statements pertaining to the children's development in cartographic language. These statements should focus on the children's development of an understanding of cartographic language rather than assuming that its development is a natural process.

Since it was concluded that a range of map design and map user factors are influential on children's map-reasoning, their competence and their performance in cartographic language, it is implied that the context in which a curriculum is placed is important to its successful implementation. Therefore, any social sciences curriculum should alert its users to the influence of such factors on children's development in cartographic language.

Because of the range of development by children in cartographic language across the concrete map-reasoning level, curriculum designers should alert teachers to use curriculum materials which are consonant with the children's competence and performance in cartographic language. This implies that any resources' lists of curriculum materials should include only those items which are suitable to the children's level of map-reasoning. This is especially relevant to comments on atlases and key reference books. These comments should be based on research evidence rather than untested statements.

Therefore, the following recommendations for curriculum developers are made. They are based on the conclusions and observations of this study. These recommendations which are not presented in any order of importance are directed at improving curriculum statements on the use of cartographic language in primary and secondary education.

1. All relevant social science curriculums should contain a statement on the children's development of competence in cartographic language.

Curriculum developers should be cognisant of the differential rates of children's development of competence in different types of cartographic signs. This awareness should be included in the curriculum as statements of guidance for teachers and as an integral part of the curriculum sequence. Curriculum development teams may need to consult with researchers in the field of cartographic language development to become aware of children's rate of development of competence in cartographic language.

2. Curriculum developers in the social sciences should become cognisant of children's development in performance in cartographic language and include this awareness in the relevant section on skill development in the curriculum.

This recommendation is included to encourage curriculum developers to concentrate on map making in the curriculum rather than map interpretation. This is because the investigator, along with researchers such as Bartz (1965), believes that children develop a better understanding of maps by making them rather than by reading them.

3. Social science curriculums which include statements concerning maps should include some statement which makes their readers aware that children's map-reasoning, competence and performance in cartographic language are influenced by a range of map design and map user factors.

Such a statement may alert the teacher using the curriculums to consider carefully the individual attributes of the children likely to encounter these curriculums. The sequence of map skills development may be accelerated if children have had enriched spatial experiences or steadied if they have not.

4. Resources to be used in implementing the mapping part of a social science curriculum should not be recommended for use by anyone unless they have been evaluated by a cartographic language consultant.

This recommendation pertains especially to atlases and globes where the use or abuse of the principles of cartographic representation is concentrated.

5.53 Implications for classroom teaching.

The conclusions of this study contain a range of useful implications for the classroom because they provide the classroom teacher with a range of insights into children's abilities in a mode of communication which has been viewed as another skill rather than a complementary mode of communication with words and numbers.

The study concluded that children at a concrete map-reasoning level, normally aged from eight years through to fifteen years, display quite a range of development in becoming competent in cartographic language. Age is an important factor in the child's map-reasoning level and in his development of competence in cartographic language. The range of development varies according to the type of map signs. Usually the children are more competent at identifying cartographic signs than comprehending them because identification is an easier process. It is apparent from the competence results that the signs which children develop more slowly include qualitative and quantitative line signs, qualitative point signs and quantitative area signs. For all of the cartographic signs sampled in this study, the development in comprehension of these signs across the concrete level of map-reasoning is quite definite. The conclusions imply the need for cartographic learning experiences consonant with the children's level of competence in cartographic language. This may not be a major problem for an experienced teacher because children's competence in cartographic language is linked strongly with age.

Since it was concluded that children aged eight years through fourteen years are at the concrete map-reasoning level, it is implied that the development of competence in cartographic language can be achieved best if the children at this reasoning level are provided with maps containing cartographic signs which do not display great amounts of distance between sign and referent. Maps of this type would include orthophotomaps (preferably coloured ones) and those containing pictorial symbols. For the older children,simple topographic maps can be used to build on the above samples. For the younger concrete map-reasoning children, vertical aerial photographs could be used as an introduction to maps. If possible, the vertical aerial photographs should be coloured.

The conclusions from this study concerning children's performance in cartographic language imply that the teacher will have greater difficulty promoting its development on a whole-class basis because age is not a significant influence on children's performance. However, the children's map-reading ability, understanding of the concept of a map, previous experiences with maps, spatial ability, verbal and nonverbal intelligence, and competence in cartographic language are influential. This implies that the teacher must treat each child individually when considering the children's development of performance in cartographic language.

The above statements imply that cartographic language should be introduced in its most realistic form to lower and middle primary children,that is, as cartographic signals. From there on, increasing abstraction of signs should take place as the children's map-reasoning level dictates. This will mean that conventional topographic maps will not be used in any depth until the children are in the middle secondary years.

These implications necessitate the teacher's becoming aware of the children's map-reasoning level, as well as their level of competence and performance in cartographic language.

These conclusions imply the need to provide the children with atlases consonant with their level of competence in cartographic language. The psychophysical approach to maps does provide teachers with insights into the children's perceptions of atlas maps. The selection of a child's atlas should be influenced by the range and difficulty of cartographic signs, the use of colour, the positioning of lettering and so on.

Therefore, the following recommendations for the classroom are made on the basis of the conclusions and observations in this study. These recommendations which are not presented in any order of importance are directed at improving classroom experiences in which cartographic language is used in both primary and secondary education.

1. Atlases and other curricular materials containing maps which are used in teaching should be consonant with the children's competence in cartographic language.

Teachers in primary and secondary schools should be cognisant of the range of signs which constitute cartographic language and of children's development of competence in cartographic language so that they are competent to provide meaningful resources for learning. Since the children display a concrete map-reasoning level, the atlases and other maps they use should reflect this level of reasoning. Therefore, maps containing cartographic signals and pictorial symbols should be prevalent in learning situations. Abstract symbols such as those on conventional topographic maps should be used sparingly only with children at the upper end of concrete map-reasoning.

2. Teachers in primary and secondary schools should encourage map making rather than map reading.

This will minimise the problem that children's performance in cartographic language and age are not closely related. It will also enable the gradual development in children of the four basic cartographic concepts - arrangement, proportion, orthogonal view and language. In the earliest years of formal education, this could take the form of drawing individual objects from an orthogonal view in signal form. Gradually the objects are related to each other in an appropriate proportion. As the children develop cognitively so they will refine their mode of representing cartographic information. Therefore, by middle secondary school, the children are consistently representing cartographic information in an abstract symbolic manner.

3. Curricular materials should not be prescribed for use in primary or secondary classrooms unless the map-reasoning level of the children has been determined.

The investigator is concerned about the extent to which the conclusions of this study are being used by commercial publishers of cartographic curricular materials. His impression, from a casual perusal of a range of commonly-used curricular materials in primary and secondary social sciences, was of an excessive use of maps containing mainly abstract signs in the middle primary years and upwards. This study concluded that children up to fourteen years of age experience difficulty with a variety of abstract signs. The publishers of these materials should ensure that the maps in their materials are as readable as the words in the text. This will enable the use of more relevant resources for the children's development of competence and performance in cartographic language.

4. Since each child is an individual learner and since he or she is influenced by a range of map user factors, then all teachers in the social sciences should be aware of each child's strengths and weaknesses for the development of cartographic language.

Once these strengths and weaknesses are known, the teacher should capitalise on the strengths and remedy the weaknesses. For example, children who work regularly in the Boy Scouts, Girl Guides or Orienteering Clubs, or whose parents are architects, surveyors or geographers, are likely to have advanced cartographic understanding. This understanding may be fostered by providing these children with compasses and measuring tapes so that they may create accurate maps. Also, the children who lag in cartographic competence may be provided with more realistic maps to suit their level of cartographic understanding.

5.6 Epilogue.

The principal values of this study are:

(a) It demonstrates that the map user is an important variable in the cartographic communication process. The map user brings to the cartographic communication situation a range of personal and background factors which influence his competence and his performance in cartographic language, as well as his map-reasoning level.

(b) It clarifies the nature of the development of competence and performance in cartographic language by children at the concrete level of map-reasoning.

(c) It establishes that a semiotic approach is a feasible method for investigating children's development of cartographic language.

The knowledge gained from this study may be used to convince cartographers, curriculum designers and teachers, that the map user is a vital element in the cartographic communication process. They should realise that the map user does not develop competence or performance in all types of cartographic signs at equal rates.

These people should also consider which factors concerned with map design and the map user influence the children's development of competence and performance in cartographic language. Then, appropriate curricular materials can be provided in learning experiences which take cognisance of factors such as the map users' home environments and their previous experiences with maps.

Also, this study extends the conventional concept of cartographic language to include standard elements, e.g. scale and direction. It extends the continuum of cartographic signs to include the range of signals located on orthophotomaps, then proceeding to mimetic and abstract symbols.

Methodologically, the use of multivariate and discriminant analyses constitutes an initial attempt to determine the relative influences of a range of map design and map user factors on the children's map-reasoning level.

Finally, the study is distinctive because it identifies a specific group of map users(the children at the concrete level of map-reasoning) and examines their development of competence and performance in cartographic language. Empirical replications should occur at either end of this map-reasoning group in order to ascertain the nature of children's developments in competence and performance in cartographic language across the four map-reasoning levels.

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APPENDIX 1 LEVELS OF SPATIAL REASONING DEVELOPMENT AS REVEALED IN MAP DRAWING.

(Snyder, Feldman and La Rossa, 1975)

LEVEL 1 No spatial correspondence except for a few elementary proximities (about 4 years).

Characterised by child's inability to distinguish between spatial proximity and logical resemblance or between spatial separation and logical difference. Yields objects on map which do not appear on model and objects on model which are not represented on map. Arrangement appears virtually arbitrary.

LEVEL 2 Partial coordination (about 4-7 years).

Characterised by recognisable but inconsistent logical and numerical correspondence. Spatial correspondence often confounded with logical resemblance or limited to small groups of proximal objects and isolated left-right relations without an overall spatial plan. Representation limited to one dimension (i.e. uses frontal view) with detail and proportion essentially unrelated to model.

LEVEL 3 Midway between partial and beginning of general coordination (about 7-8 years).

Characterised by inconsistent coordination, i.e. reasonable logical and numerical correspondence but with a mixture of perspective (e.g. frontal, 45°, 90°) and viewpoints, in poor but recognisable proportion to model. Larger groups of objects now linked together to produce primitive overall representations of model, often with "photograph-like" detail.

LEVEL 4 Beginning of general projective and Euclidean coordination (about 8-10 years).

Characterised by items in good logical and numerical correspondence and arranged according to a crude two-way system of reference (i.e. width and depth) with a consistent 45° or 90° perspective. A legitimate two-dimensional representation of the model often with some evidence of abstraction, but with as yet inaccurate scaling—relative sizes of objects often proportional, but distances (especially heights in the 45° perspective) remain distorted.

LEVEL 5 Mastery of distances and proportions (about 10-12 years).

Characterised by complete coordination of logical and numerical with spatial correspondences. Although not formally scaled with metrics and fractional reduction, an adequate diagrammatic representation of the model. A consistent 90° perspective with clear evidence of abstraction and symbolisation.

LEVEL 6 The abstract plan with metric coordinates (about 12-15 years).

Characterised by complete coordination, totally accurate scaling, a consistent 90° perspective, and use of abstract symbolisation.

APPENDIX 2 SCORING BASES FOR CHILDREN'S MAP DRAWINGS USING THE SPATIAL CONCEPTS OF ARRANGEMENT, PROPORTION, PERSPECTIVE AND ABSTRACTION/ SYMBOLISATION

(Snyder, Feldman and La Rossa, 1975)

ARRANGEMENT

LEVEL 1 No logical correspondence to model. Score 1

LEVEL 2 Objects arranged by logical properties and/ or small group proximities without reference to an overall spatial plan, often with inaccurate numerical correspondence, e.g. objects in lines, similar or proximal items bunched inappropriately, objects clinging to sides of paper, etc.. Score 2

LEVEL 3 Objects in recognisable, but poor spatial correspondence to model with accurate numerical correspondence (except for trees) e.g. one lake on left side, one hill on right side, one road and one river on bottom, rotary roughly centred with two houses off rotary and two businesses, one on either side of north/south road, the cluster D approximates criteria in ID level 3, etc.. Score 3

LEVEL 4 At least ten major objects on map overlap area indicated on overlay, and Feature Cluster D approximates criteria in ID level 4. Score 4

LEVEL 5 At least ten major objects on map fill at least one-third of area indicated on overlay, remaining objects at least overlap, and Feature Cluster D approximates criteria in ID level 5. Score 5

LEVEL 6 At least ten major objects on map fill at least one-half of area indicated on overlay, remaining objects fill at least one-third of area, and Feature Cluster D approximates criteria in ID level 6. Score 6

PROPORTION

LEVEL 1 No logical or "realistic" proportion. Score 1

LEVEL 2 Recognisable and "realistic" proportion in relative size of objects on map which is, however, not related to model. Score 2

LEVEL 3 Relative size of all objects on map roughly related to relative size on model, e.g. houses roughly the same size (30%), left-side business smaller than right-side business, hill larger than lake, river narrower than lake, roads roughly the same width (30%), rotary smaller than lake, trees roughly the same size (30%), etc.. Score 3

LEVEL 4 Relative size of objects on map reasonably related to relative size on model, e.g. houses close to same size and about as long as right-side business (20%), right-side business somewhat larger than left-side business, lake about two-thirds size of hill, roads close to equal width (20%), with driveways about one-third of road width, river slightly narrower than three road segments, which are about equal (20%), rotary about one-third size of lake and Cluster D approximates criteria in IID, level 4. Distances remain distorted. Score 4

LEVEL 5 Relative sizes as in #4 above with distances 20% of overlay; Cluster D also approximates criteria in IID, level 5. Score 5

LEVEL 6 Relative sizes and distances within 10% disagreement with overlay and Cluster D also approximates criteria in IID, level 6. Score 6

PERSPECTIVE

LEVEL 1 No recognisable perspective. Score 1

LEVEL 2 Consistent front view, *not* a symbol, or *primarily* a front view with the possible exception of the lake, river, roads, driveways (and parking lots). Score 2

LEVEL 3 Mix of front and/or 45° and/or 90° or a consistent 45° from several viewpoints. Score 3

LEVEL 4 Consistent 45° perspective from *one* viewpoint or a consistent 90° with only *minor* intrusion of 45° (i.e., 3 or 4 individual features or perhaps *all* instances of only *one* incidental feature, e.g. trees, vehicles). Score 4

LEVEL 5 Consistent 90° perspective with *reasonable* proportion (as defined below). Score 5

LEVEL 6 Consistent 90° perspective with good proportion (as defined below) Score 6

Note : Reasonable proportion = VC, level 4
Good proportion = VC, level 5

ABSTRACTION/SYMBOLISATION

LEVEL 1 No logical correspondence between map representation and model. Score 1

LEVEL 2 Objects are represented in detail, much of which does not correspond to that on model (i.e. idiosyncratic representations). Score 2

LEVEL 3 Objects are represented in "photograph-like" detail most of which corresponds to that on model, or detail is omitted, but inconsistently. Score 3

LEVEL 4 Evidence of limited abstraction, e.g. some detail is omitted in a consistent fashion, perhaps through use of a realistic 90° perspective. Score 4

LEVEL 5 Obvious evidence of consistent abstraction and some efforts at symbolisation, e.g. much detail is omitted in a consistent fashion, perhaps through use of icons and/or labels. Score 5

LEVEL 6 Objects are represented exclusively with abstract symbols in conjunction with a key. Score 6

APPENDIX 3

MAP REPRESENTATION CATEGORIES

(Based on a Free Recall Sketch Map, e.g. Home to School) (after Shemyakin, 1962)

Stage	Age	Criteria		
1	6-8	* Drawing of travel route not streets - using a mental route through locality. *Beginning on lower edge of paper and drawing "away from self". *All turns presented accurately - turns coinciding with real position of body. *Few to no side streets - streets lack names, ie. Non Verbalised Drawing. *Use of "individual" scale - middle section with greatest accuracy, overestimation of initial section by 1/3, underestimation of terminal section by 1/2	INCREASING GRADATION AND SUCCESSIVENESS OF SPACE RELATIONS	"Route" Method
2		*More complex than first stage. *Offshoots of side streets begin to appear, but with few connections with each other.		
3	12	*The form of closed aggregate of transport routes appear with greater frequency. *Local Objects (trees, home) appear, with poor space relations between objects and the bunching of objects. *Locality names included and serve as bearings, i.e. Verbalised Drawing. *Real body position not important, but drawing still not orientated "away from self".		Beginning of "Survey" Method
4		*Beginning of mental survey *Beginning of general configuration or scheme. *"Sections" of locality develop.		"Survey" Method

Stage	Age	Criteria		
		*Local objects disappear. Local points begin to appear, presented first in a row, often scattered, starting from a known one. *No scale change of initial or terminal section.		
5		*A systematic presentation of space relations, beginning from a specific point and using it as a constant or main orientor.		
6		*A systematic presentation of space relations beginning from any point.	↓	↓

(after Wilson, 1978)

APPENDIX 4

CODE NUMBER | / |

MAP SIGNS TEST - PART ONE

MAP A

INSTRUCTIONS

1. Hold your map so that the name - SINGLETON - is at the top.
2. You may use any information on the map sheet including the notes around the edges.
3. Some questions have special instructions included.
4. The letters of the alphabet on the map help you to find places named in the questions.
5. Use coloured pencils in your answers.
6. If you have any questions after you start, put your hand up and I will help you.
7. Answer as many questions as you can.
8. You may now try the practice question.

Practice Question

These questions are the sort you will meet in the study. Try them now.

A. (i) Which sign on the map shows a RESERVOIR / WATER TOWER ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

____

____

(b) (Place a circle around the best answer in this question.)

Towns such as SINGLETON have RESERVOIRS / WATER TOWERS because -

1. there are no hills around,
2. the town's water supply is treated and stored there,
3. the towns are located far from water,
4. the farms are on the low land. (2)

9. Now answer the questions in Part One.

A. (i) Which sign on the map shows NORTH ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

Walking NORTH-WEST from SINGLETON you would come to -

1. Redbournberry (A),
2. Singleton Heights (B),
3. Doughboy Hollow (C),
4. Whittingham (D). (2)

(c) (Place a circle around the best answer in this question.)

Which of the following tells you the DIRECTION of the GOLF COURSE (E) from the SEWAGE TREATMENT PLANT (F) at SINGLETON:

1. 2 kilometres,
2. a straight line,
3. north-east,
4. 7 kilograms ? (2)

(d) (Place a circle around the best answer in this question.)

If SOUTH is at the bottom of the map, the most NORTHERN bend of the HUNTER RIVER is near -

1. Scotts Flat (G),
2. Reservoir Hill (H),
3. Combo (I),
4. Redbournberry (A) ? (2)

B. (i) Which sign on the map shows HOW FAR PLACES ARE APART ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

If I walked in a straight line from SINGLETON HEIGHTS (B) to RESERVOIR HILL (H), how many kilometres would I walk?

1. I cannot tell,
2. 1 kilometre,
3. 2 kilometres,
4. 4 kilometres. (2)

(c) (Place a circle around the best answer in this question.)

Which of the following tells you HOW FAR PLACES ARE APART on the map:

1. A straight line,
2. 24 kilometres,
3. 60 degrees,
4. 4 centimetres to 1 kilometre. (2)

(d) (Place a circle around the best answer in this question.)

If REDBOURNBERRY (A) is almost 5 KILOMETRES from WHITTINGHAM (D) then NO PART OF THE MAP is MORE THAN -

1. 10,
2. 7,
3. 4,
4. 2 kilometres from SINGLETON GOLF COURSE (E). (2)

C. (i) Which sign on the map shows A ROAD ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below) (2)

(b) (Place a circle around the best answer in this question.)

The major road to the EAST of SINGLETON passes through -

1. Whittingham (D),
2. Redbournberry (A),
3. Doughboy Hollow (C),
4. Singleton Heights (B). (2)

(c) (Place a circle around the best answer in this question.)

The NEW ENGLAND HIGHWAY (J) is the most important road on the map because -

1. it runs near the Main Northern Railway,
2. it is the only road into Singleton,
3. it passes through Singleton and links Singleton with Singleton Heights,
4. it is the only road to cross the Hunter River. (2)

(d) (Place a circle around the best answer in this question.)

It was possible for SINGLETON to have a regular road pattern of squares or rectangles because -

1. Singleton is located on flat ground,
2. most people live in Singleton,
3. the Main Northern Railway passes on the edge of the town,
4. Singleton is built on hills. (2)

D. (i) Which sign on the map shows A RIVER ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

The HUNTER RIVER near COMBO (I) is -

1. a long, narrow body of flowing water,
2. dry sand,
3. a long, narrow lake,
4. a flooded body of water. (2)

(c) (Place a circle around the best answer in this question.)

The main feature between SCOTTS FLAT (G) and DOUGHBOY HOLLOW CREEK (K) is a -

1. railway,
2. river,
3. hill,
4. cemetery. (2)

(d) (Place a circle around the best answer in this question.)

The HUNTER RIVER on the map flows from -

1. Redbournberry (A) to Scotts Flat (G),
2. Scotts Flat (G) to Redbournberry (A),
3. Redbournberry (A) to Combo (I),
4. Combo (I) to Long Point (L). (2)

E. (i) Which sign on the map shows A HOUSE ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

The buildings at (M) are -

1. scattered farm houses,
2. city houses,
3. army houses (barracks),
4. factories. (2)

(c) (Place a circle around the best answer in this question.)

The buildings at REDBOURNBERRY near (N) are likely to be -

1. homes,
2. buildings for farming or industry,
3. a school,
4. a church. (2)

(d) (Place a circle around the best answer in this question.)

The buildings at ROUGHIT (O) consist of -

1. a small group of factories,
2. a small group of homes,
3. scattered farm houses,
4. a city. (2)

F. (i) Which sign on the map shows A BRIDGE ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

If you wanted to go the shortest way, by car, from SINGLETON to SINGLETON HEIGHTS you would cross the HUNTER RIVER at -

1. No. 1,
2. No. 2,
3. No. 3,
4 No. 4. (2)

(c) (Place a circle around the best answer in this question.)

The BRIDGE at (P) was built so that the NEW ENGLAND HIGHWAY could cross a -

1. railway line,
2. hill,
3. small river valley,
4. forest. (2)

(d) (Place a circle around the best answer in this question.)

Bridge No. 5 is longer than bridge No. 3 because -

1. the Hunter River Valley is narrower at bridge No. 3,
2. bridge No. 3 is closer to Singleton,
3. there is more farmland near bridge No. 5,
4. the road crossing bridge No. 3 is not as important as that crossing bridge No. 5. (2)

G. (i) Which sign on the map shows A FOREST ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

____

____

____

(b) (Place a circle around the best answer in this question.)

The thickest forest is found near -

1. Singleton Heights (B),
2. Reservoir Hill (H),
3. Dangars Creek (Q),
4. Combo (I). (2)

(c) (Place a circle around the best answer in this question.)

The trees near STINKING GULLY (R) may be called a forest because -

1. there are many trees growing close together,
2. they are gum trees,
3. a creek flows through the area,
4. the trees are growing on mountains. (2)

(d) (Place a circle around the best answer in this question.)

The forest around DANGARS CREEK (Q) is thickest along the creek because -

1. there are no roads there,
2. this is the highest land,
3. this is the place where the trees get most moisture,
4. the rough country stops cattle from grazing there. (2)

H. (i) Which sign on the map shows the TOWN (URBAN) AREA ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?
(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)
Which of the following places is a town?

1. Singleton Heights (B),
2. Whittingham (D),
3. Reservoir Hill (H),
4. Redbournberry (A). (2)

(c) (Place a circle around the best answer in this question.)
SINGLETON may be called a town because it has -

1. houses built close together,
2. a shopping area,
3. buildings used for schools and a hospital,
4. buildings which are used for houses, shops, schools and hospitals. (2)

(d) (Place a circle around the best answer in this question.)
More people shop in SINGLETON than in SINGLETON HEIGHTS (B) because -

1. Singleton Heights is mainly an area of homes,
2. Singleton has more large shops,
3. More people live on the north side of the Hunter River,
4. Singleton has a golf course. (2)

CODE NUMBER /

MAP SIGNS TEST - PART ONE

MAP B

INSTRUCTIONS

1. Hold your map so that the name - SINGLETON - is at the top.
2. You may use any information on the map sheet including the notes around the edges.
3. Some questions have special instructions included.
4. The letters of the alphabet on the map help you to find places named in the questions.
5. Use coloured pencils in your answers.
6. If you have any questions after you start, put your hand up and I will help you.
7. Answer as many questions as you can.
8. You may now try the practice question.

Practice Question

These questions are the sort you will meet in the study. Try them now.

A. (i) Which sign on the map shows a RESERVOIR / WATER TOWER ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

____

____

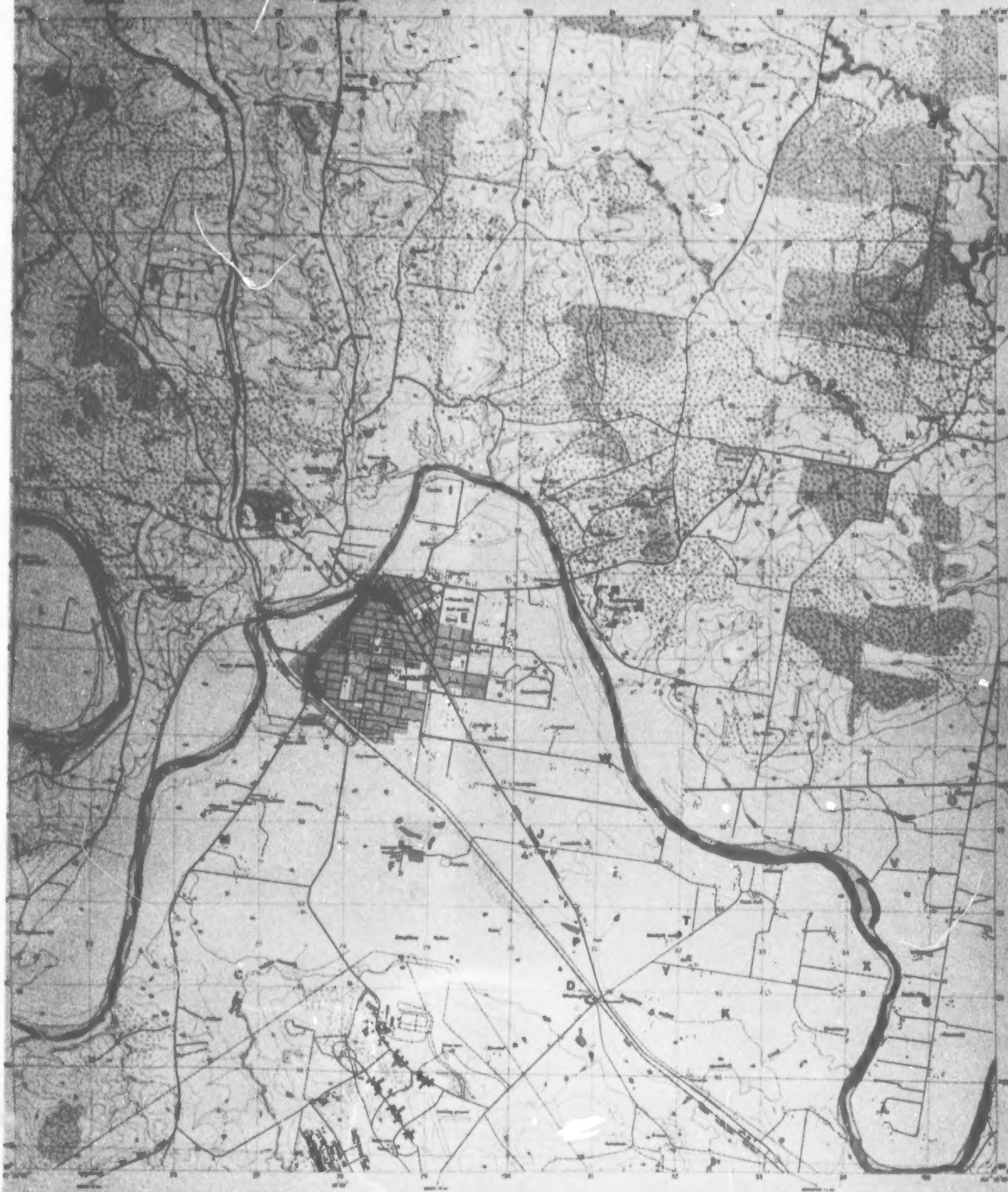
(b) (Place a circle around the best answer in this question.)

Towns such as SINGLETON have RESERVOIRS / WATER TOWERS because -

1. there are no hills around,
2. the town's water supply is treated and stored there,
3. the towns are located far from water,
4. the farms are on the low land. (2)

9. Now answer the questions in Part One.

SINGLETON



SCALE 1:25 000

A. (i) Which sign on the map shows NORTH ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

Walking NORTH-WEST from SINGLETON you would come to -

1. Redbournberry (A),
2. Singleton Heights (B),
3. Doughboy Hollow (C),
4. Whittingham (D). (2)

(c) (Place a circle around the best answer in this question.)

Which of the following tells you the DIRECTION of the GOLF COURSE (E) from the SEWAGE TREATMENT PLANT (F) at SINGLETON:

1. 2 kilometres,
2. a straight line,
3. north-east,
4. 7 kilograms ? (2)

(d) (Place a circle around the best answer in this question.)

If SOUTH is at the bottom of the map, the most NORTHERN bend of the HUNTER RIVER is near -

1. Scotts Flat (G),
2. Reservoir Hill (H),
3. Combo (I),
4. Redbournberry (A) ? (2)

B. (i) Which sign on the map shows HOW FAR PLACES ARE APART ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

If I walked in a straight line from SINGLETON HEIGHTS (B) to RESERVOIR HILL (H), how many kilometres would I walk?

1. I cannot tell,
2. 1 kilometre,
3. 2 kilometres,
4. 4 kilometres. (2)

(c) (Place a circle around the best answer in this question.)

Which of the following tells you HOW FAR PLACES ARE APART on the map:

1. A straight line,
2. 24 kilometres,
3. 60 degrees,
4. 4 centimetres to 1 kilometre. (2)

(d) (Place a circle around the best answer in this question.)

If REDBOURNBERRY (A) is almost 5 KILOMETRES from WHITTINGHAM (D) then NO PART OF THE MAP is MORE THAN -

1. 10,
2. 7,
3. 4,
4. 2 kilometres from SINGLETON GOLF COURSE (E). (2)

C. (i) Which sign on the map shows A ROAD ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below) (2)

(b) (Place a circle around the best answer in this question.)

The major road to the EAST of SINGLETON passes through -

1. Whittingham (D),
2. Redbournberry (A),
3. Doughboy Hollow (C),
4. Singleton Heights (B). (2)

(c) (Place a circle around the best answer in this question.)

The NEW ENGLAND HIGHWAY (J) is the most important road on the map because -

1. it runs near the Main Northern Railway,
2. it is the only road into Singleton,
3. it passes through Singleton and links Singleton with Singleton Heights,
4. it is the only road to cross the Hunter River. (2)

(d) (Place a circle around the best answer in this question.)

It was possible for SINGLETON to have a regular road pattern of squares or rectangles because -

1. Singleton is located on flat ground,
2. most people live in Singleton,
3. the Main Northern Railway passes on the edge of the town,
4. Singleton is built on hills. (2)

D. (i) Which sign on the map shows A RIVER ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

The HUNTER RIVER near COMBO (I) is -

1. a long, narrow body of flowing water,
2. dry sand,
3. a long, narrow lake,
4. a flooded body of water. (2)

(c) (Place a circle around the best answer in this question.)

The main feature between SCOTTS FLAT (G) and DOUGHBOY HOLLOW CREEK (K) is a -

1. railway,
2. river,
3. hill,
4. cemetery. (2)

(d) (Place a circle around the best answer in this question.)

The HUNTER RIVER on the map flows from -

1. Redbournberry (A) to Scotts Flat (G),
2. Scotts Flat (G) to Redbournberry (A),
3. Redbournberry (A) to Combo (I),
4. Combo (I) to Long Point (L). (2)

E. (i) Which sign on the map shows A HOUSE ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

____

____

____

(b) (Place a circle around the best answer in this question.)

The buildings at (M) are -

1. scattered farm houses,
2. city houses,
3. army houses (barracks),
4. factories. (2)

(c) (Place a circle around the best answer in this question.)

The buildings at REDBOURNBERRY near (N) are likely to be -

1. homes,
2. buildings for farming or industry,
3. a school,
4. a church. (2)

(d) (Place a circle around the best answer in this question.)

The buildings at ROUGHIT (O) consist of -

1. a small group of factories,
2. a small group of homes,
3. scattered farm houses,
4. a city. (2)

F. (i) Which sign on the map shows A BRIDGE ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

If you wanted to go the shortest way, by car, from SINGLETON to SINGLETON HEIGHTS you would cross the HUNTER RIVER at -

1. No. 1,
2. No. 2,
3. No. 3,
4 No. 4. (2)

(c) (Place a circle around the best answer in this question.)

The BRIDGE at (P) was built so that the NEW ENGLAND HIGHWAY could cross a -

1. railway line,
2. hill,
3. small river valley,
4. forest. (2)

(d) (Place a circle around the best answer in this question.)

Bridge No. 5 is longer than bridge No. 3 because -

1. the Hunter River Valley is narrower at bridge No. 3,
2. bridge No. 3 is closer to Singleton,
3. there is more farmland near bridge No. 5,
4. the road crossing bridge No. 3 is not as important as that crossing bridge No. 5. (2)

G. (i) Which sign on the map shows A FOREST ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

The thickest forest is found near -

1. Singleton Heights (B),
2. Reservoir Hill (H),
3. Dangars Creek (Q),
4. Combo (I). (2)

(c) (Place a circle around the best answer in this question.)

The trees near STINKING GULLY (R) may be called a forest because -

1. there are many trees growing close together,
2. they are gum trees,
3. a creek flows through the area,
4. the trees are growing on mountains. (2)

(d) (Place a circle around the best answer in this question.)

The forest around DANGARS CREEK (Q) is thickest along the creek because -

1. there are no roads there,
2. this is the highest land,
3. this is the place where the trees get most moisture,
4. the rough country stops cattle from grazing there. (2)

H. (i) Which sign on the map shows the TOWN (URBAN) AREA ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

____

____

____

(b) (Place a circle around the best answer in this question.)

Which of the following places is a town?

1. Singleton Heights (B),
2. Whittingham (D),
3. Reservoir Hill (H),
4. Redbournberry (A). (2)

(c) (Place a circle around the best answer in this question.)

SINGLETON may be called a town because it has -

1. houses built close together,
2. a shopping area,
3. buildings used for schools and a hospital,
4. buildings which are used for houses, shops, schools and hospitals. (2)

(d) (Place a circle around the best answer in this question.)

More people shop in SINGLETON than in SINGLETON HEIGHTS (B) because -

1. Singleton Heights is mainly an area of homes,
2. Singleton has more large shops,
3. More people live on the north side of the Hunter River,
4. Singleton has a golf course. (2)

APPENDIX 5

CODE NUMBER /

QUANTITATIVE MAP SIGNS

The questions in this set are designed to find out how well you understand map signs which measure things.

Each of the SIX (6) parts refers to a map. Make sure you are looking at the correct map before you answer the questions.

You may use coloured pencils.

If you have any questions raise your hand and the supervisor will help you.

You may now answer the test questions.

Thank you,

R. GERBER

Look at the map of SINGLETON to answer these questions.

A. (i) Which sign on the map shows the HEIGHT OF THE LAND ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?
(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)
Which place on the map is highest?
1. Combo (I),
2. Reservoir Hill (H),
3. Singleton Heights (B),
4. Whittingham (D). (2)

(c) (Place a circle around the best answer in this question.)
You can read from the map that the bank of the HUNTER RIVER near RESERVOIR HILL (H) is steep because -
1. the brown lines are close together,
2. there are no trees growing there,
3. there is a bend in the river,
4. the opposite side of the river is flat. (2)

(d) (Place a circle around the best answer in this question.)
Airports are usually built on large areas of flat land. Which of these places would be best for an airport?
1. Singleton Heights (B),
2. Obanvale (S),
3. Whittingham (D),
4. Stinking Gully (R) (2)

Look at the map of FUN ISLAND. It shows the numbers of tourists who travel between the island towns each day. Now answer the questions.

8. (i) Which sign(s) on the map show the NUMBER OF TOURISTS MOVING AMONG THE ISLAND TOWNS ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

Most tourists move between -

1. Mara and Point,
2. Lang and Vale,
3. Grove and Ebor,
4. Sol and Tor. (2)

(c) (Place a circle around the best answer in this question.)

The map shows that the NUMBERS OF TOURISTS moving between SOL and TOR are similar to the numbers moving between LANG and POINT because -

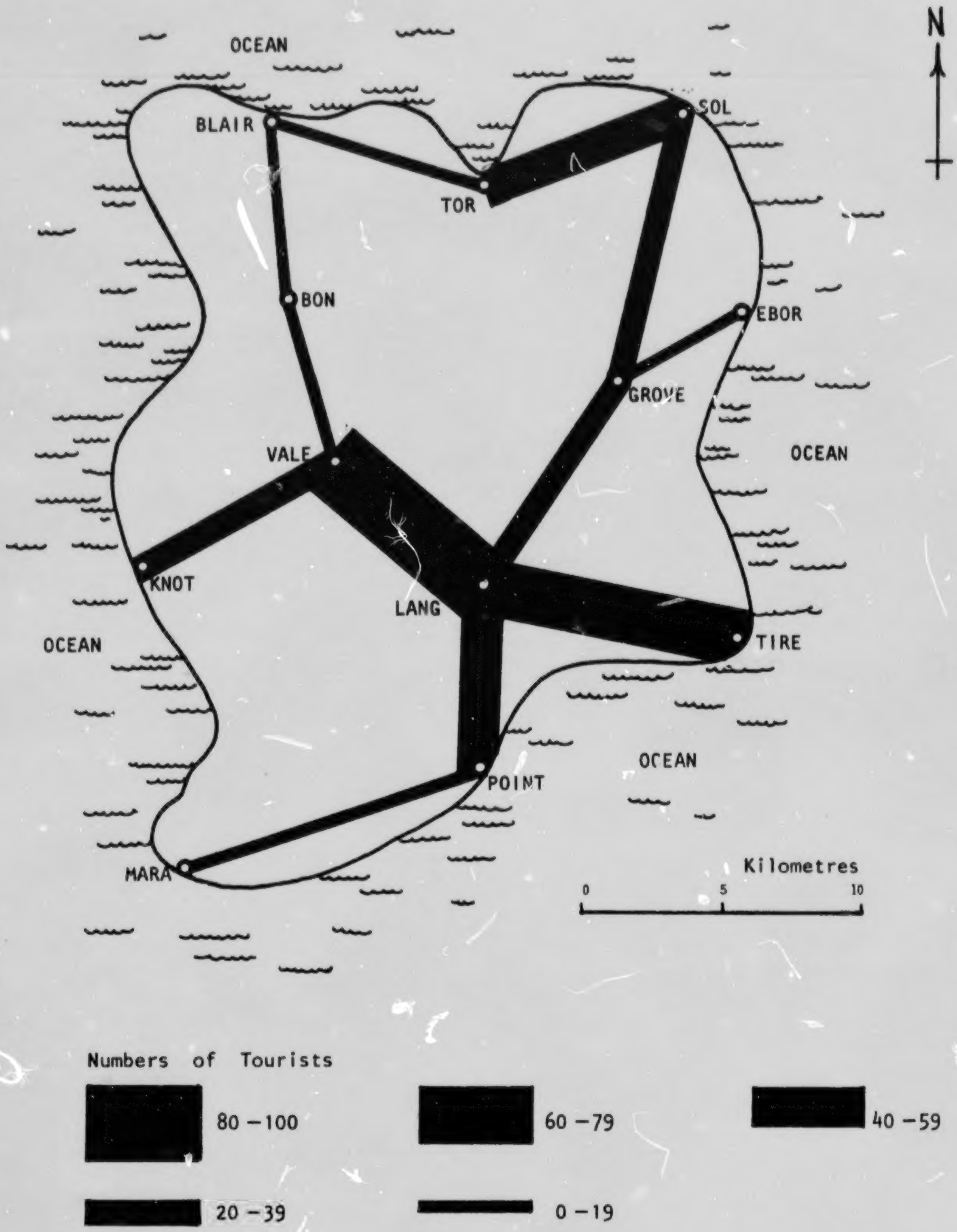
1. these places are on the coast,
2. these places are at both ends of the islands,
3. Lang and Vale are inland centres,
4. the lines between both sets of places are of similar thickness. (2)

(d) (Place a circle around the best answer in this question.)

The tourist centre on the island which most people visit is -

1. Blair,
2. Vale,
3. Lang,
4. Tire. (2)

FUN ISLAND - DAILY MOVEMENT OF TOURISTS


OCEAN
BLAIR
SOL
TOR
BON
EBOR
GROVE
VALE
OCEAN
KNOT
LANG
TIRE
OCEAN
OCEAN
POINT
MARA
N
Kilometres
0
5
10
Numbers of Tourists
80 - 100
60 - 79
40 - 59
20 - 39
0 - 19

Look at the map of AUSTRALIA showing the populations of Australian cities with more than 50,000 people in 1976. Now answer the questions.

C. (i) Which sign(s) on the map show the NUMBER OF PEOPLE in each city?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

____

____

____

(b) (Place a circle around the best answer in this question.)

Which city has the most people.

1. Mt Isa,
2. Ipswich,
3. Canberra,
4. Rockhampton. (2)

(c) (Place a circle around the best answer in this question.)

The map shows LAUNCESTON, MT ISA and GOLD COAST have similar numbers of people because -

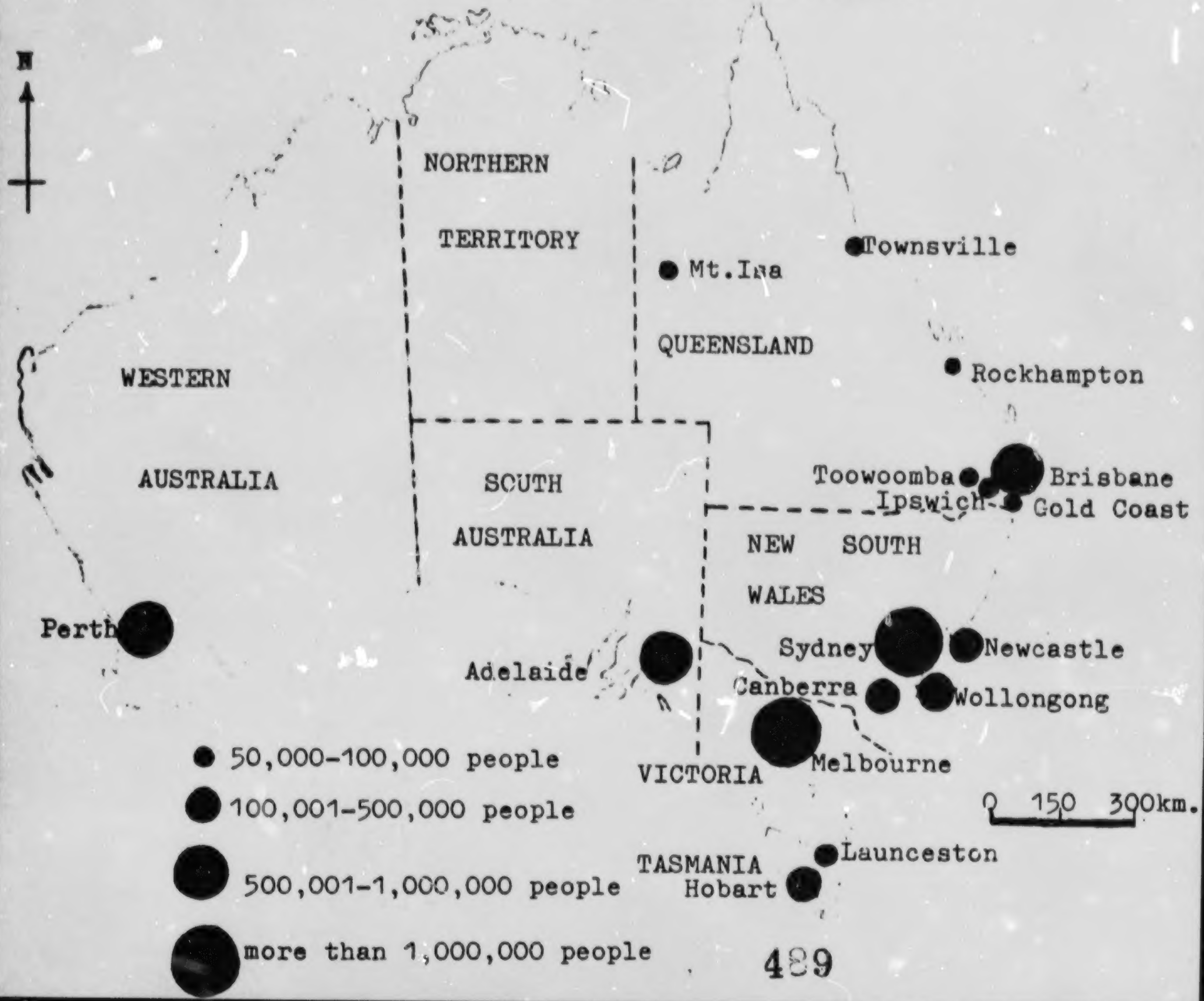
1. they are in the same State,
2. the circles showing their population are the same size,
3. they are all in eastern Australia,
4. they are near to cities with larger numbers of people. (2)

(d) (Place a circle around the best answer in this question.)

The circles on the map show that most people in AUSTRALIA live -

1. near the coast from Brisbane to Adelaide,
2. in Queensland, Northern Territory and Western Australia,
3. in New South Wales,
4. in the western half of Australia. (2)

AUSTRALIA - CITIES OF MORE THAN 50,000 PEOPLE (1976)


N
NORTHERN
TERRITORY
WESTERN
AUSTRALIA
QUEENSLAND
SOUTH
AUSTRALIA
NEW SOUTH
WALES
VICTORIA
TASMANIA
Townsville
Mt.Isa
Rockhampton
Toowoomba
Brisbane
Ipswich
Gold Coast
Perth
Adelaide
Sydney
Newcastle
Canberra
Wollongong
Melbourne
Launceston
Hobart
0 150 300km.
● 50,000-100,000 people
● 100,001-500,000 people
● 500,001-1,000,000 people
● more than 1,000,000 people

Look at the map of TIN ISLAND to answer these questions.

D. (i) Which sign on the map shows HOW MANY BICYCLES THERE ARE IN EACH TOWN ?

Draw the sign here. (2)

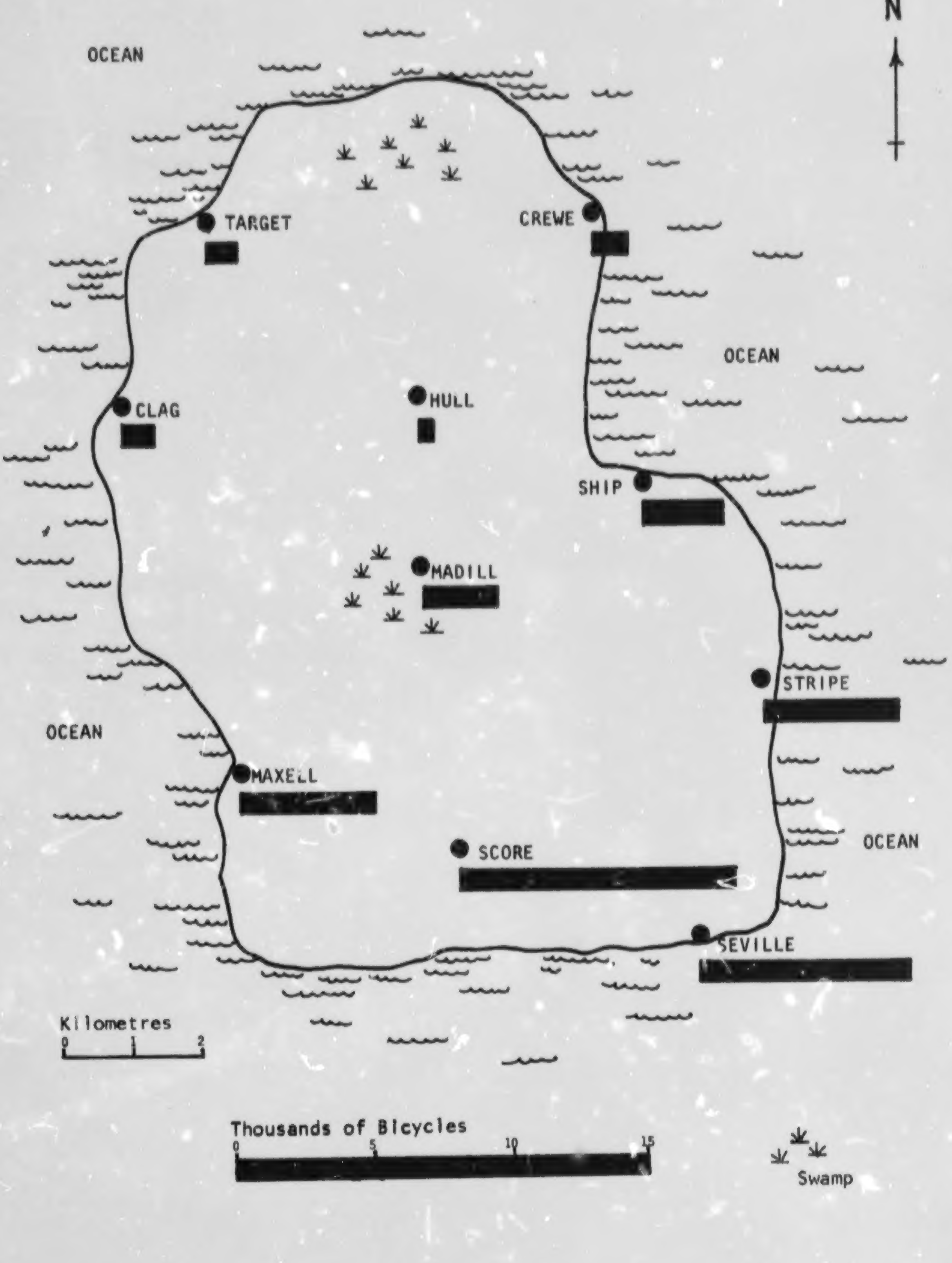
(ii) (a) What does this sign tell you?
(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)
Which town has most bicycles?
1. Hull,
2. Score,
3. Ship,
4. Maxell. (2)

(c) (Place a circle around the best answer in this question.)
The map shows MAXELL and STRIPE have similar numbers of bicycles because -
1. both towns are near the ocean,
2. the bars beneath their names are of similar length,
3. Maxell has a bicycle factory,
4. both towns are on an island. (2)

(d) (Place a circle around the best answer in this question.)
Which town is likely to be situated in very hilly country?
1. Seville,
2. Madill,
3. Hull,
4. Score. (2)

TIN ISLAND - NUMBERS OF BICYCLES IN MAIN TOWNS


N
OCEAN
TARGET
CREWE
OCEAN
HULL
CLAG
SHIP
MADILL
STRIPE
OCEAN
MAXELL
OCEAN
SCORE
SEVILLE
Kilometres
0
1
2
Thousands of Bicycles
0
5
10
15
Swamp

Look at the map of BIG ISLAND and then answer these questions.

E. (i) Which sign(s) on the map show HOW MANY PEOPLE THERE ARE IN EACH SQUARE KILOMETRE ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

____

____

____

(b) (Place a circle around the best answer in this question.)

Which town is surrounded by areas containing fewest people in each square kilometre?

1. Coco,
2. Tima,
3. Laka,
4. Mova. (2)

(c) (Place a circle around the best answer in this question.)

The area around LAKA is shaded more lightly than around MOVA because -

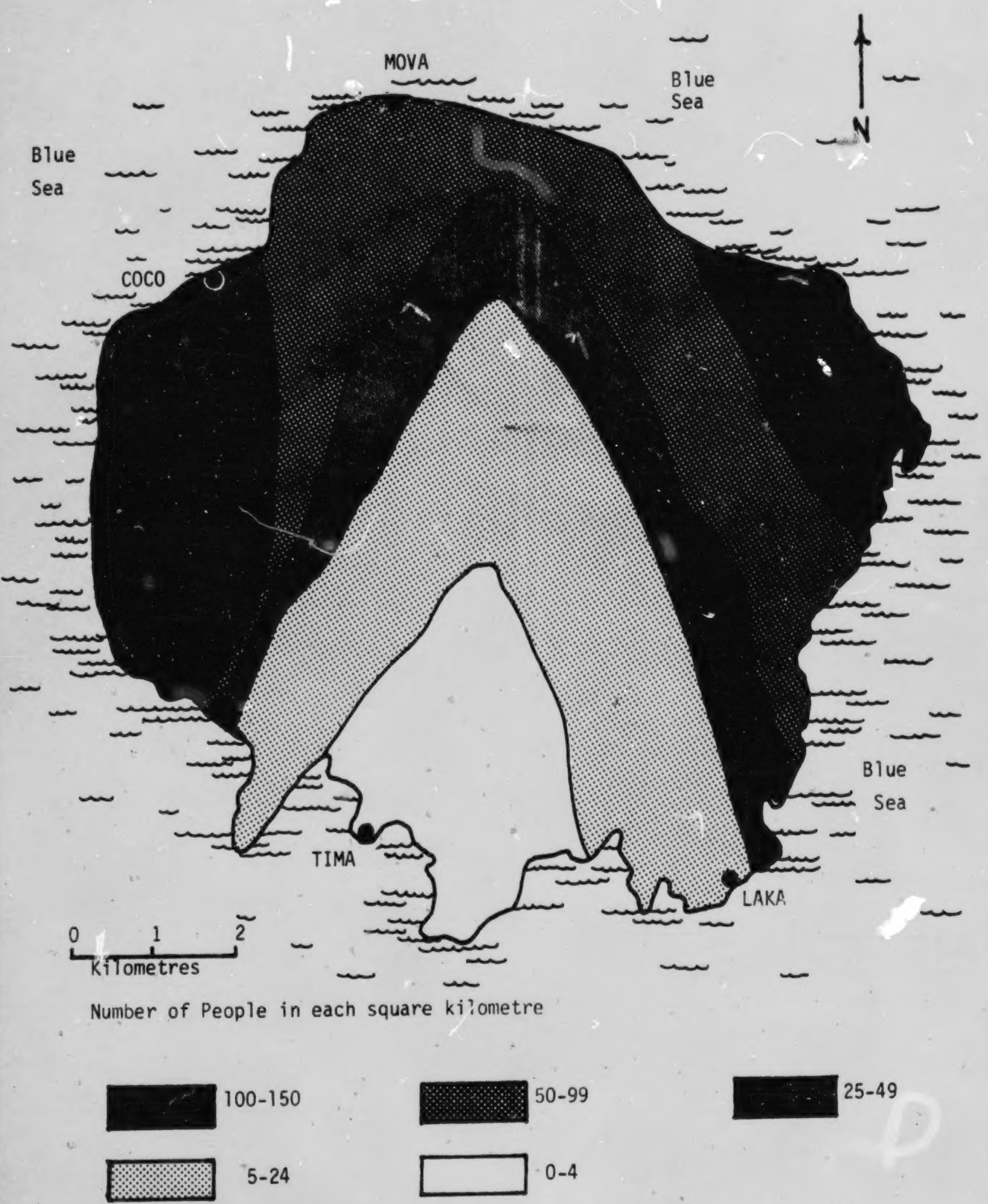
1. Laka is on the coast,
2. Mova has a motor car factory,
3. more people per square kilometre live around Mova,
4. Tima is closer to Laka. (2)

(d) (Place a circle around the best answer in this question.)

Which town is likely to contain most people?

1. Tima,
2. Laka,
3. Mova,
4. Coco. (2)

BIG ISLAND - Population Density


MOVA
Blue Sea
N
Blue Sea
COCO
Blue Sea
TIMA
LAKA
0
1
2
Kilometres
Number of People in each square kilometre
100-150
50-99
25-49
5-24
0-4

Look at the coloured map of the island and then answer these questions.

F. (i) Which sign(s) on the map show HOW HIGH THE LAND IS ?

Draw the sign here. (2)

(ii) (a) What does this sign tell you?

(Write your answer in the space below.) (2)

(b) (Place a circle around the best answer in this question.)

Which of the following places is highest:

1. Horner,
2. Haber,
3. Majore,
4. Feld. (2)

(c) (Place a circle around the best answer in this question.)

The green parts of the map show areas of the island which are -

1. covered by mountains,
2. perfectly flat land,
3. hills with rivers and a few mountains,
4. flat land with low hills. (2)

(d) (Place a circle around the best answer in this question.)

If the winds brought rain to SULA from the sea then the mountains will stop much rain from falling at -

1. Majore,
2. Garon,
3. Haber,
4. Sula. (2)

APPENDIX 6

CODE NUMBER /

COLOUR ON MAP SIGNS

This exercise aims to find out your ideas on the use of colour in map signs.

You will work with TWO (2) types of maps. For both types of map you will have a coloured and a black-and-white map.

The questions will tell you which map to look at for your answers.

If you have any questions raise your hand and I will help you.

Thank you,
R. GERBER

SINGLETON

SERIES R831

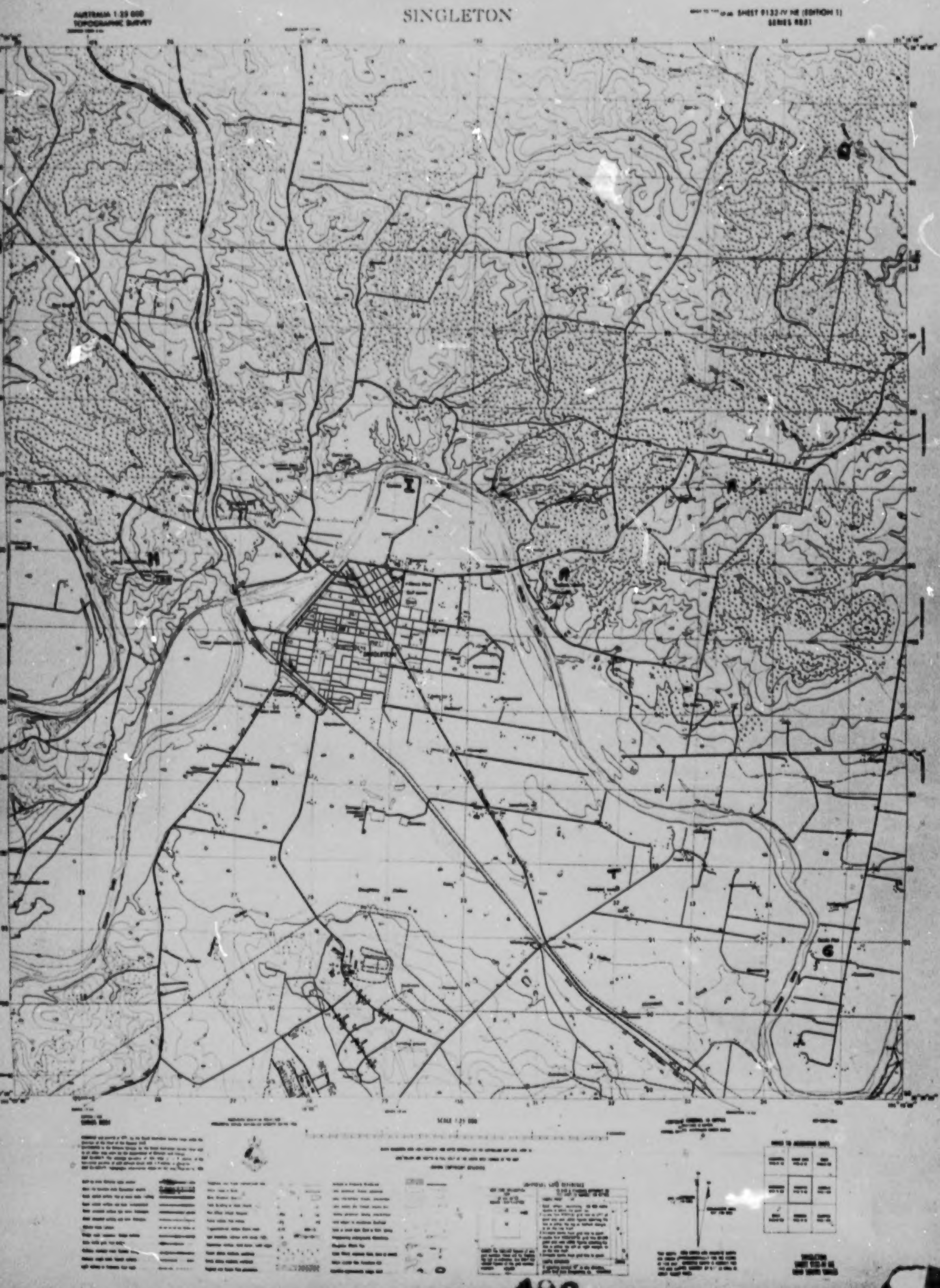
SCALE 1:25 000

495

A

SINGLETON
SHEET 9132-IV NE

B



AUSTRALIA 1:25 000
TOPOGRAPHIC SURVEY
SINGLETON
SHEET 9132-IV NE (EDITION 1)
SERIES R831
SCALE 1:25 000

496

A. Look at the coloured and black-and-white copies of MAP 'A'.
Now answer these questions.

1. Which map is easier to read? ☐ Coloured
(Tick one of the boxes.) ☐ Black-and-white

2. Why did you choose that map?
(Write your answer in the space below.)

____

____

____

3. Which features do you see more clearly on the COLOURED map?
List these: (a) ______________________________
(b) ______________________________
(c) ______________________________
(d) ______________________________

4. Which features do you see more clearly on the BLACK-AND-WHITE map?
List these: (a) ______________________________
(b) ______________________________
(c) ______________________________
(d) ______________________________

5. Look at the BLACK-AND-WHITE map, near SCOTTS FLAT (G). Is most of the land growing crops?
(Tick one of the boxes.) YES ☐ NO ☐ I CANNOT TELL ☐

6. Look at the COLOURED map, near COMBO (I). Is most of the land growing crops?
(Tick one of the boxes.) YES ☐ NO ☐ I CANNOT TELL ☐

7. Look at the BLACK-AND-WHITE map, near SINGLETON HEIGHTS (B). Do the houses have different coloured roofs?
(Tick one of the boxes.) YES ☐ NO ☐ I CANNOT TELL ☐

8. Look at the COLOURED map, near SINGLETON. Do the houses have different coloured roofs?

(Tick one of the boxes.) YES ☐ NO ☐ I CANNOT TELL ☐

9. Look at the BLACK-AND-WHITE map. There are TWO (2) RESERVOIRS and TWO (2) WATER TOWERS near RESERVOIR HILL (H).

(Tick one of the boxes.) YES ☐ NO ☐ I CANNOT TELL ☐

10. Look at the COLOURED map. There are TWO (2) RESERVOIRS and ONE (1) WATER TOWER near RESERVOIR HILL (H).

(Tick one of the boxes.) YES ☐ NO ☐ I CANNOT TELL ☐

B. Look at the coloured and black-and-white copies of MAP 'B'.

Now answer these questions.

1. Which map do you prefer?

(Tick one of the boxes.)

☐ Coloured

☐ Black-and-white

2. Why did you choose that map?

(Write your answer in the space below.)

3. Which features do you see more clearly on the COLOURED map?

List these:

(a)

(b)

(c)

(d)

4. Which features do you see more clearly on the BLACK-AND-WHITE map?

List these: (a) ______________________________

(b) ______________________________

(c) ______________________________

(d) ______________________________

5. There is a WINDBREAK (a line of trees to stop winds) on the BLACK-AND-WHITE map. It is near -

1. Combo (I)
2. Randwick Lodge (T)
3. Redbournberry (A)
4. Scotts Flat (G)

(Place a circle around the best answer in this question.)

6. There is a WINDBREAK (a line of trees to stop winds) on the COLOURED map. It is near -

1. Singleton Heights (B)
2. Wattle Ponds Creek (U)
3. Whittingham (D)
4. Roughit (O)

(Place a circle around the best answer in this question.)

7. There are FORESTS on the BLACK-AND-WHITE map. The forest is thickest around -

1. Redbournberry (A)
2. Stinking Gully (R)
3. Dangars Creek (Q)
4. Reservoir Hill (H)

(Place a circle around the best answer in this question.)

8. Which of these ROADS on the COLOURED map is sealed (bitumened)?

1. Road V
2. Road W
3. Road X
4. Road Y

(Place a circle around the best answer in this question.)

C. Look at BOTH COLOURED MAPS to answer the next set of questions.

1. The colours of the signs are easier to read on -

(Tick one of the boxes.) Map 'A' ☐ Map 'B' ☐

2. Why did you choose this map?

(Write your answer in the space below.)

____

____

____

3. The colours of the signs are closer to real life on -

(Tick one of the boxes.) Map 'A' ☐ Map 'B' ☐

4. Why did you choose this map?

(Write your answer in the space below.)

____

____

____

5. Which map gives you a better idea of the types of ROADS on the map?

(Tick one of the boxes.) Map 'A' ☐ Map 'B' ☐

6. Why did you choose this map?

(Write your answer in the space below.)

____

____

____

7. Which map gives you a better idea of the exact positions of TREES?

(Tick one of the boxes.) Map 'A' ☐ Map 'B' ☐

8. Why did you choose this map?

(Write your answer in the space below.)

____

____

____

APPENDIX 7

CODE NUMBER /

MAP GENERALISATION

This set of questions refers to TWO (2) SETS of maps.

Set 1 = Beenleigh A
Beenleigh B

Set 2 = Petrie 13
Caboolture - Sheet 38

These questions aim to find out how well you can understand maps at different scales and how the size of the map signs helps you read the maps.

Each question will refer you to parts of ONE of the maps. Refer only to that map to answer the question.

If you have any questions raise your hand and I will help you.

You may now answer the questions.

Thank you,

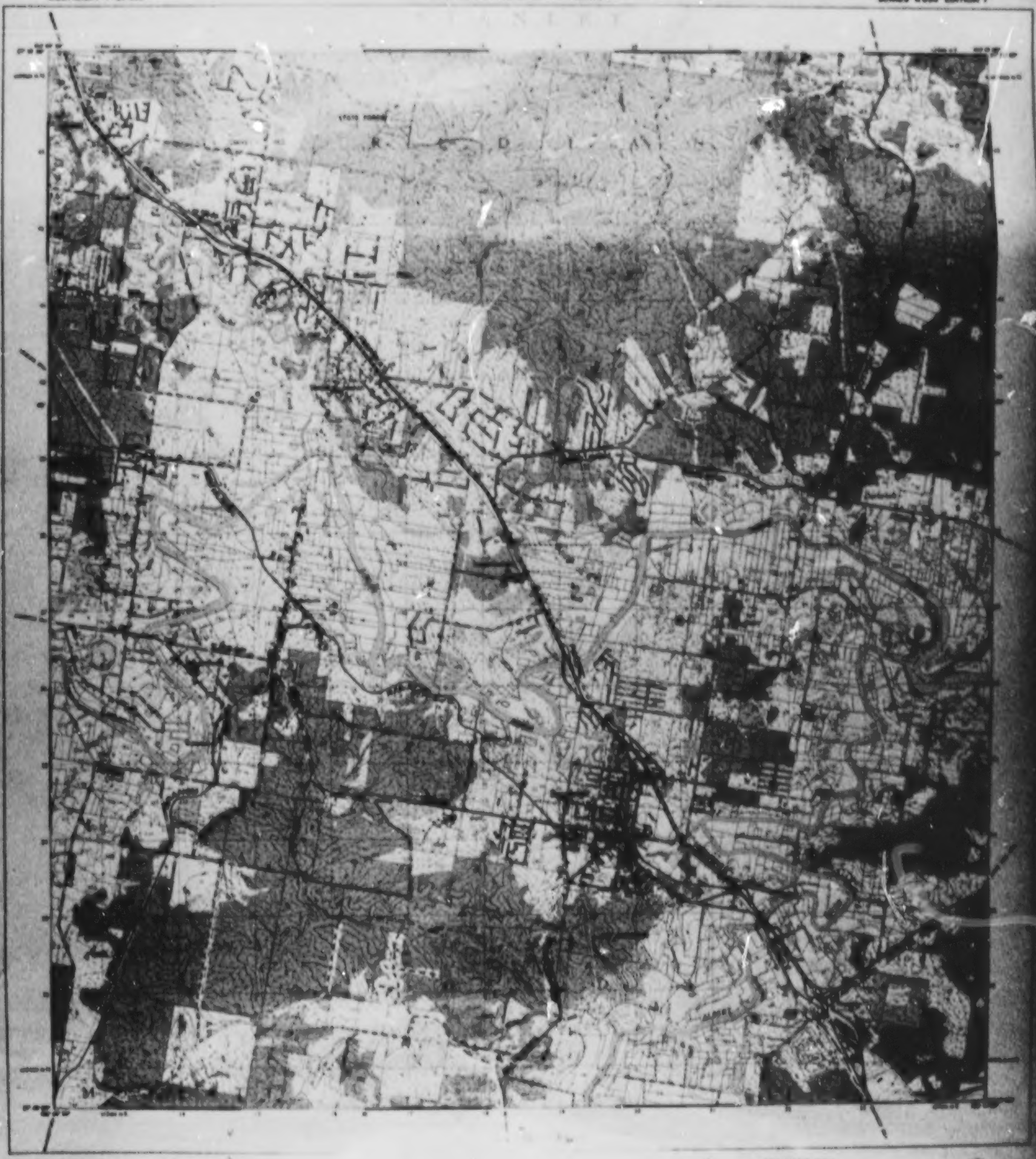
R. GERBER

QUEENSLAND
AUSTRALIA 1:25 000

BEENLEIGH

QUEENSLAND TOPOGRAPHIC SURVEY

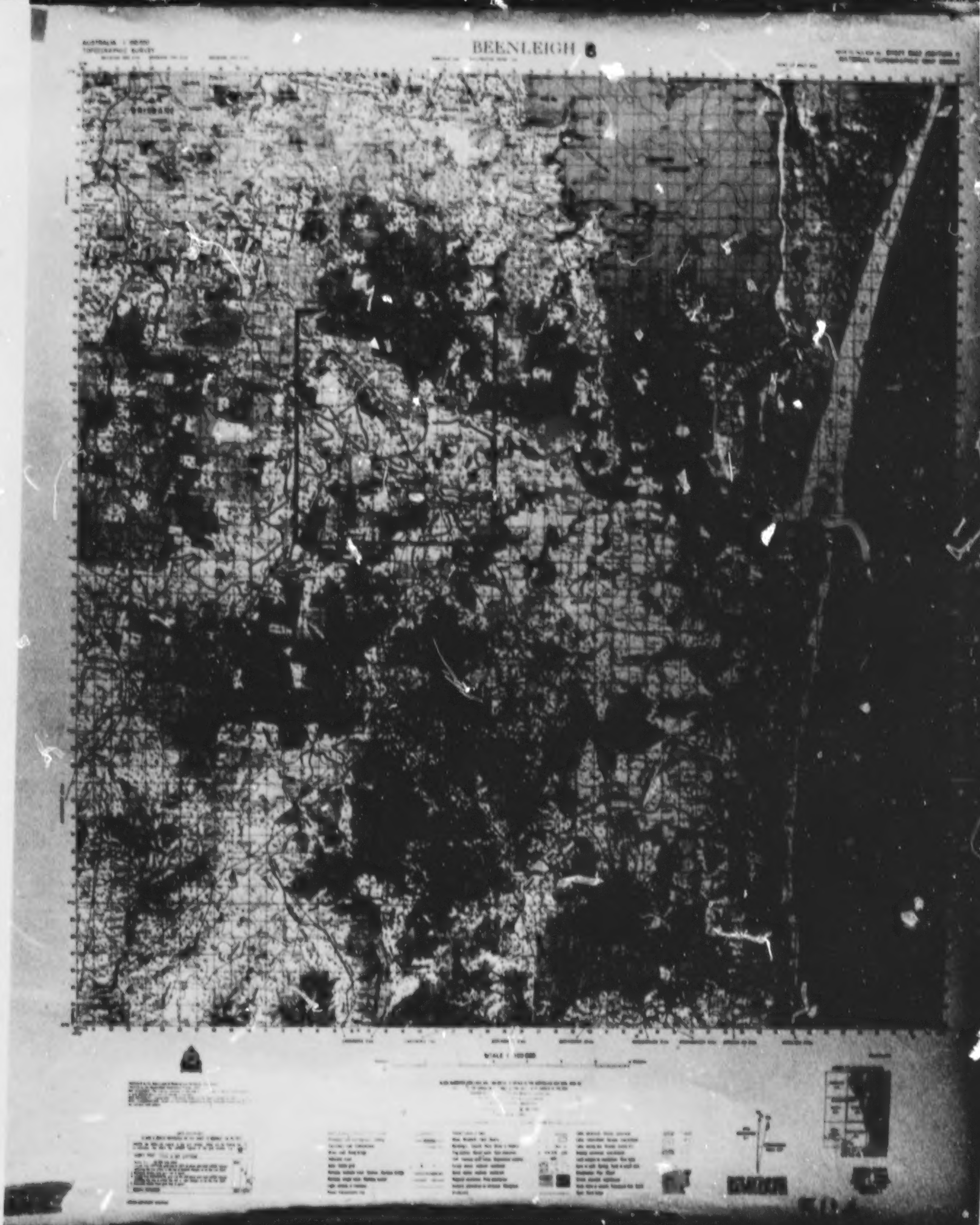
SHEET [illegible]
SERIES [illegible] EDITION 1



CONTOUR INTERVAL 10 METRES
AUXILIARY CONTOUR INTERVAL 5 METRES

CROWN COPYRIGHT RESERVED

503


AUSTRALIA 1:100 000
TOPOGRAPHIC SURVEY
BEENLEIGH
SCALE 1:100 000

A. Look at BEENLEIGH - Map A to answer these questions.

Write your answers in the blank spaces. If you cannot tell from the map place an "X" in the space for the answer.

1. TWO main RIVERS are (a) ______________________________ and (b) ____________________________. (2)

2. TWO key ROADS are (a) ______________________________ and (b) ____________________________. (2)

3. The HIGHEST LAND AROUND BEENLEIGH is ________________________ ________________________. It is ______________ metres high. (2)

4. A SWAMPY AREA near BEENLEIGH is near ________________________ ________________________. (1)

5. BEENLEIGH'S SHOWGROUND is located in the ____________________ ________________________ part of the town. (1)

6. Look at the lower half of the map. Which of these roads is less important?

Beaudesert Beenleigh Road ☐ Logan River Road ☐ I cannot tell ☐

(Tick one of the boxes to answer this question.)

B. Look at BEENLEIGH - Map B. You will be asked questions only about the area inside the heavy black line.

You may use the information in the margins of the map.

Write your answers in the blank spaces. If you cannot tell from the map place an "X" in the space for the answer.

1. TWO main RIVERS are (a) ______________________________ and (b) ____________________________. (2)

2. TWO key ROADS are (a) ______________________________ and (b) ____________________________. (2)

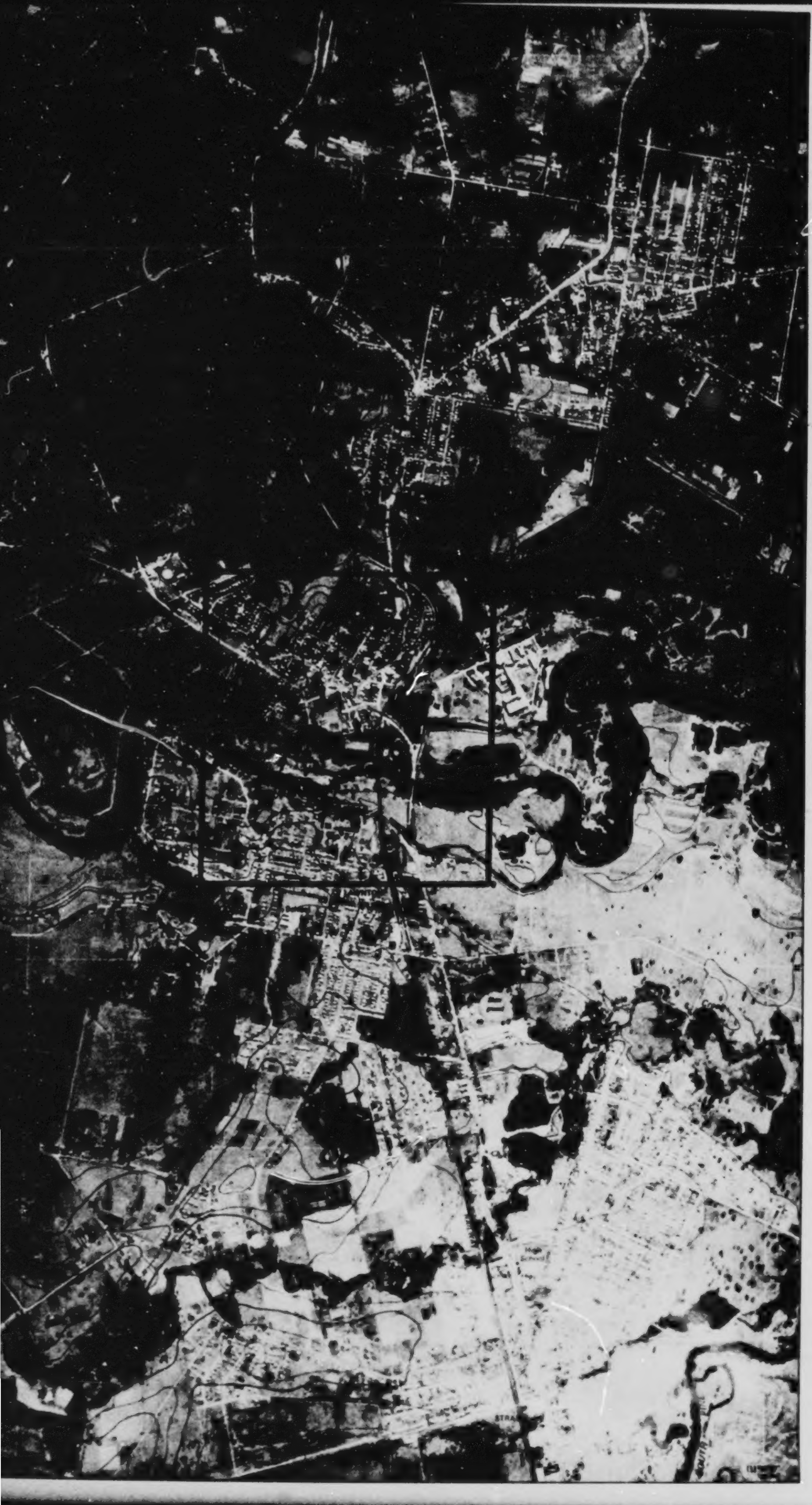
QUEENSLAND
1:2000 SERIES

ORTHOPHOTO MAP

NORTH COAST RAILWAY
ROAD
ROAD
PARADE

SCALE 1:2000

506



1:10 000 ORTHOPHOTO MAP

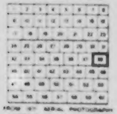
CABOOLTURE 9443
SHEET 38

SCALE 1:10 000

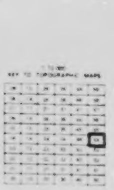
CONTOUR INTERVAL 5 METRES

CROWN COPYRIGHT RESERVED

KEY TO ORTHOPHOTO MAPS



KEY TO TOPOGRAPHIC MAPS



ORTHOPHOTO MAP

CABOOLTURE 9443

SHEET 38

QUEENSLAND

1:10 000

507

3. The HIGHEST LAND AROUND BEENLEIGH is ____________________

____________________. It is __________ metres high. (2)

4. A SWAMPY AREA near BEENLEIGH is near ____________________

____________________. (1)

5. BEENLEIGH'S SHOWGROUND is located in the ____________________

____________________ part of the town. (1)

6. Look at the lower half of the enclosed area on the map. Which of these roads is less important? (Tick one of the boxes to answer this question.)

Beaudesert Beenleigh Road ☐ Logan River Road ☐ I cannot tell ☐

C. Look at the PETRIE map to answer these questions.

Write your answers in the blank spaces. If you cannot tell from the map place an "X" in the space for the answer.

1. The RIVER on the map is the ____________________. (1)

2. Petrie town is the meeting place of the ____________________ Road (Highway) and the ____________________ Railway. (2)

3. The ROAD crosses the RAILWAY. (Tick one of the boxes to answer this question.)

TRUE ☐ FALSE ☐ I CANNOT TELL ☐

4. The area beside the Railway Station on the Petrie town side is used for

____________________. (1)

5. PETRIE HOTEL is located ____________________

____________________. (1)

6. The buildings below the river on the map look like ____________________

____________________. (1)

7. How many bridges are there across the river? ____________________ (1)

D. Look at the CABOOLTURE map.

You will be asked questions only about the area inside the heavy black line.

You use the information in the margins of the map.

Write your answers in the blank spaces. If you cannot tell from the map place an "X" in the space for the answer.

1. The RIVER on the map is the ______________________________ . (1)

2. Petrie town is the meeting place of the ____________________ Road (Highway) and the ______________________ Railway. (2)

3. The ROAD crosses the RAILWAY. (Tick one of the boxes to answer this question.)
TRUE ☐ FALSE ☐ I CANNOT TELL ☐

4. The area on the Petrie town side of the Railway Station is used for ____ . (1)

5. PETRIE HOTEL is located ____________________________________ ____________________________ . (1)

6. The buildings below the river on the map look like _______________ ____________________________ . (1)

7. How many bridges cross the river? __________________ (1)

APPENDIX 8

CODE NUMBER ☐ /

MAP LETTERING

This set of questions is designed to show how well you understand the placing of names on maps.

Some of the questions refer to Map 'X' and some to Map 'Y'.

Use only the map to which the question refers.

Spell the names of the features as they are spelt on the map.

Write your answers in the spaces provided.

If you have any questions raise your hand and I will help you.

You may now answer the questions.

Thank you,

R. GERBER

A. Look at the map for ISLAND Y.

Now answer these questions.

1. The name of the island "Y" is ______________________________

2. The rivers on the island are ______________________________

____

______________________________.

3. The highest mountain is ______________________________

which is ______________ metres high.

4. The only line of mountains is the ______________________ Range.

5. The towns which are situated inland are ______________________

and ______________________.

6. The most important towns are ______________________________

and ______________________.

7. The only marked lowland is ______________________________.

8. The road which does not cross a river is the road from ______________

______________________ to ______________________________.

9. The most EASTERLY TOWN is ______________________________.

10. To drive from JAMESVILLE to LYCON you would cross the ______________

______________________ River.

473.

B. Look at the map for ISLAND X.

Now answer the questions.

1. The name of island "X" is ______________________________.

2. The rivers on the island are ______________________________

____

______________________________.

3. The highest mountain is ______________________________

which is ______________ metres high.

4. The only line of mountains is the ______________________ Range.

5. The towns which are situated inland include ______________________

and ______________________________.

6. The most important towns are ______________________________

and ______________________________.

7. The only marked lowland is ______________________________.

8. A road which does cross a river is the road from ______________

______________________ to ______________________________.

9. The most SOUTHERLY TOWN is ______________________________.

10. To drive from TONY to BEYER you would cross the ______________

______________ River.

C. Look at BOTH MAPS.

Why did you find the map of ISLAND X EASIER to read than the map of ISLAND Y.

1. ____________________

____

2. ____________________

____

3. ____________________

____

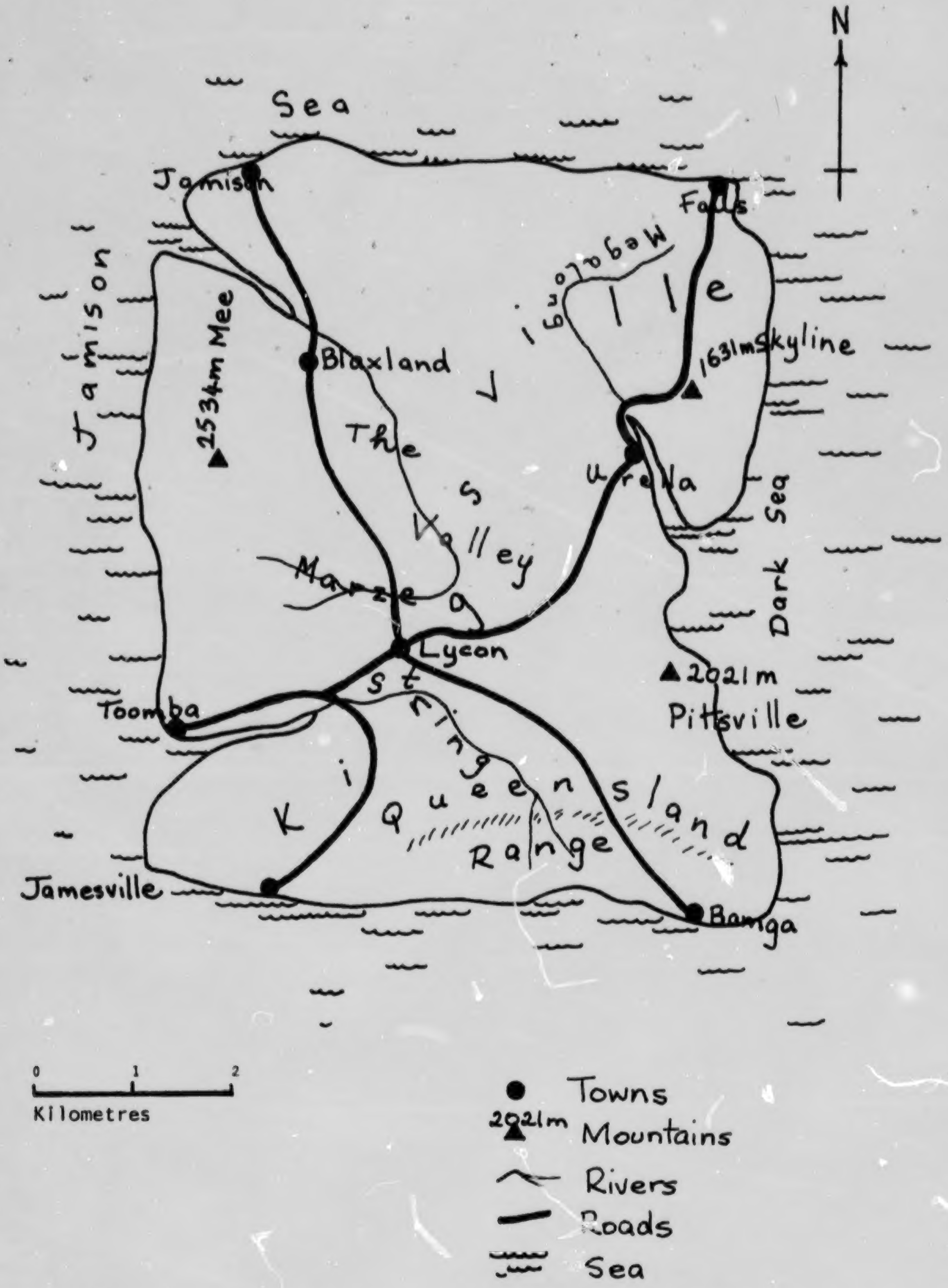
4. ____________________

____

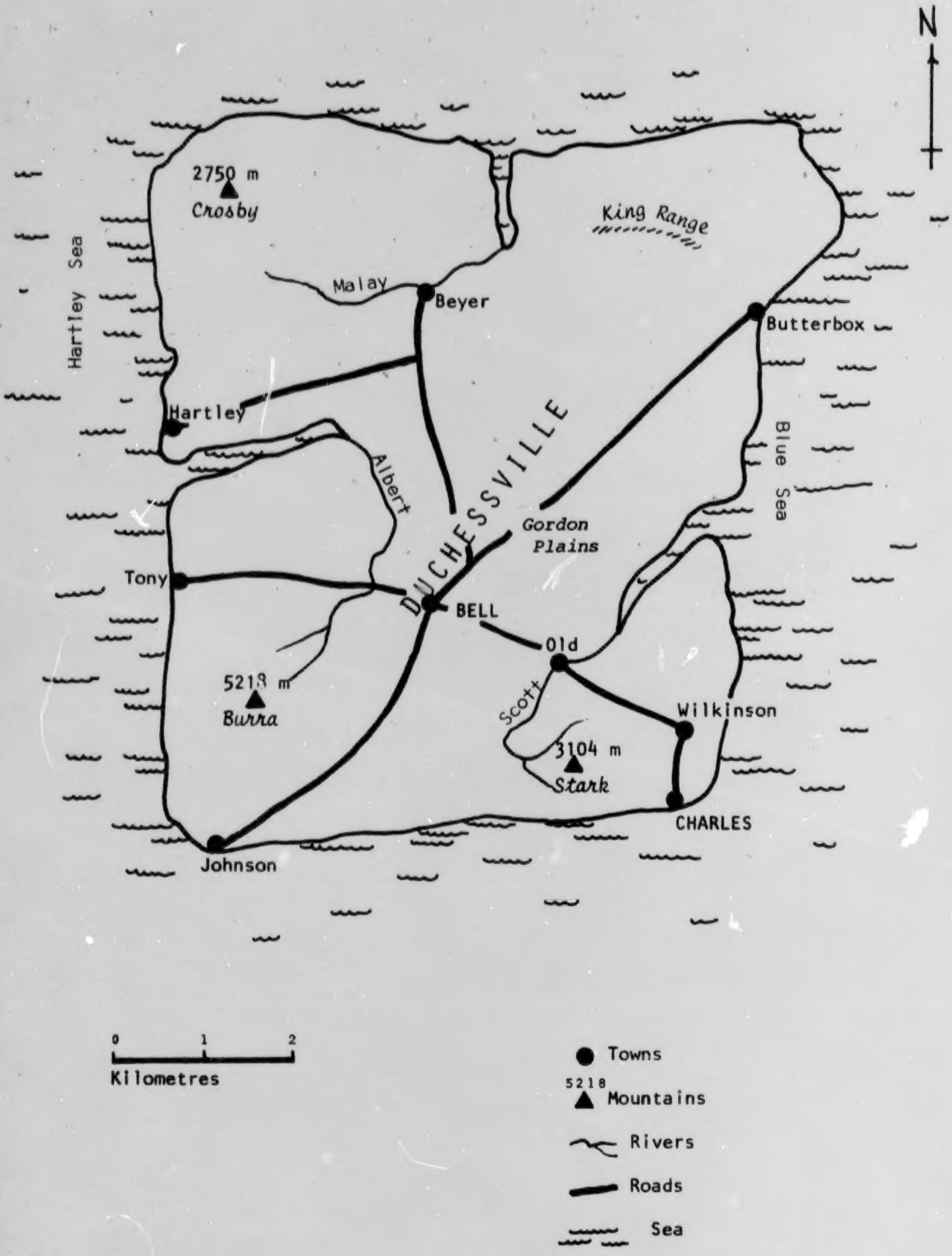
5. ____________________

____

ISLAND "Y"


N
Sea
Jamison
Falls
Megalong
Jamison
2534m Mee
Blaxland
L i l l e
1631m Skyline
The
s
Valley
Urella
Dark Sea
Marzea
Lycon
▲2021m
Pittsville
s t
r i n g e
Toomba
K i
Queensland
Range
Jamesville
Bamga
0
1
2
Kilometres
● Towns
2021m ▲ Mountains
Rivers
Roads
Sea

ISLAND "X"


N
2750 m
Crosby
King Range
Hartley Sea
Malay
Beyer
Butterbox
Hartley
Blue Sea
Albert
DUCHESSVILLE
Gordon Plains
Tony
BELL
Old
5218 m
Burra
Scott
Wilkinson
3104 m
Stark
CHARLES
Johnson
0
1
2
Kilometres
Towns
5218
Mountains
Rivers
Roads
Sea

APPENDIX 9

CONCEPT OF A MAP

1. What is a map?
   (Write your answer in the space below.) (2)

   ____

   ____

   ____

2. Which of the SIX examples can be called a map?
   (Tick any of the boxes.)

   (a) ☐ (b) ☐ (c) ☐

   (d) ☐ (e) ☐ (f) ☐

   (4)

3. Write down why you chose each map.

   Map ( ) ______________________________

   ____

   Map ( ) ______________________________

   ____

   Map ( ) ______________________________

   ____

   Map ( ) ______________________________

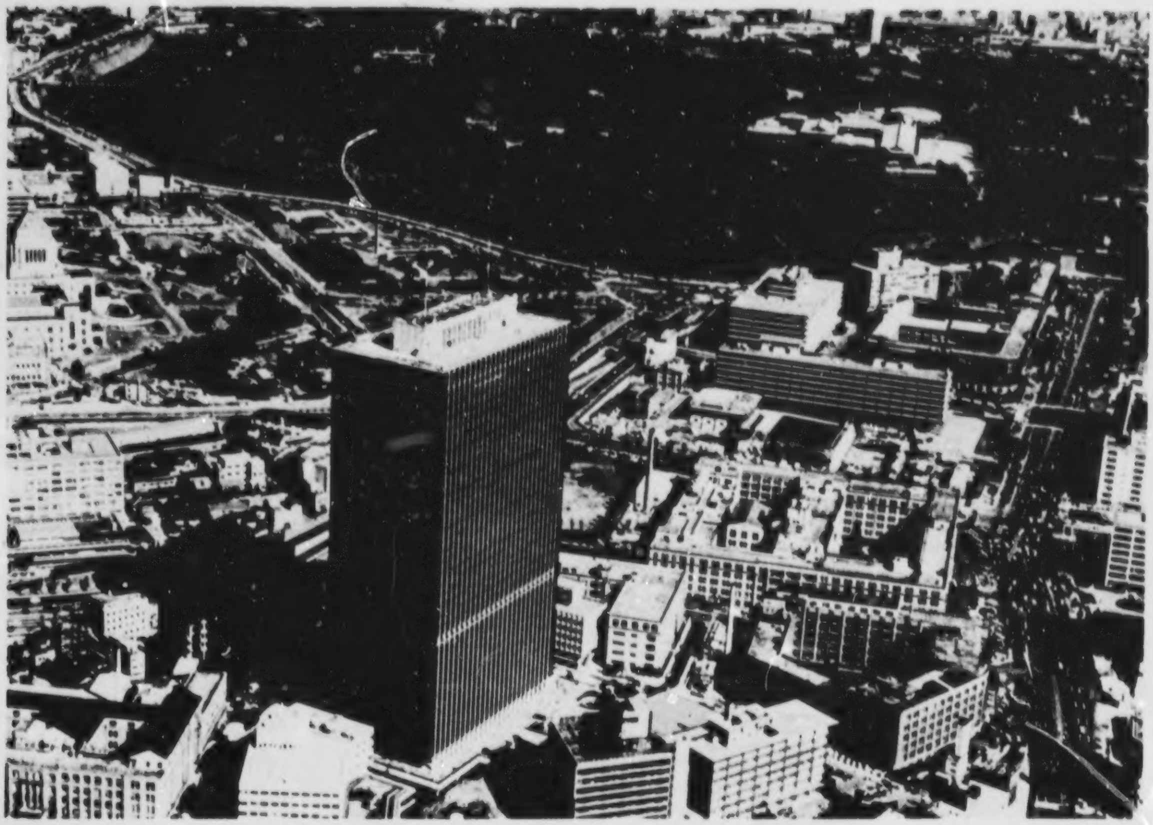
   ____

   Map ( ) ______________________________

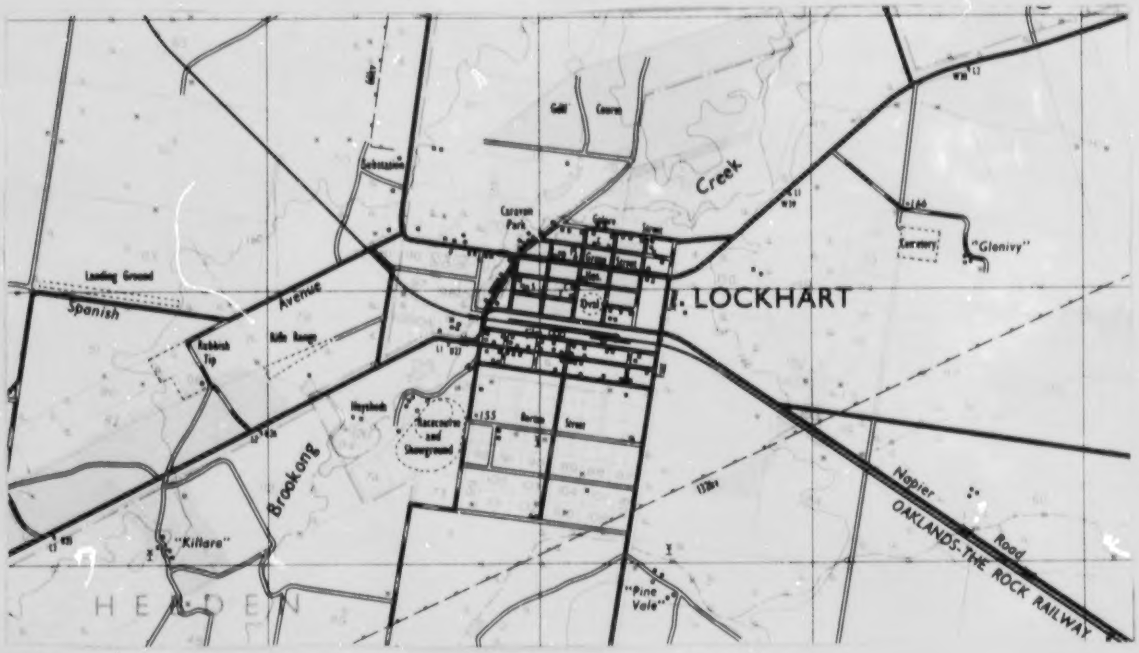
   ____

   (4)

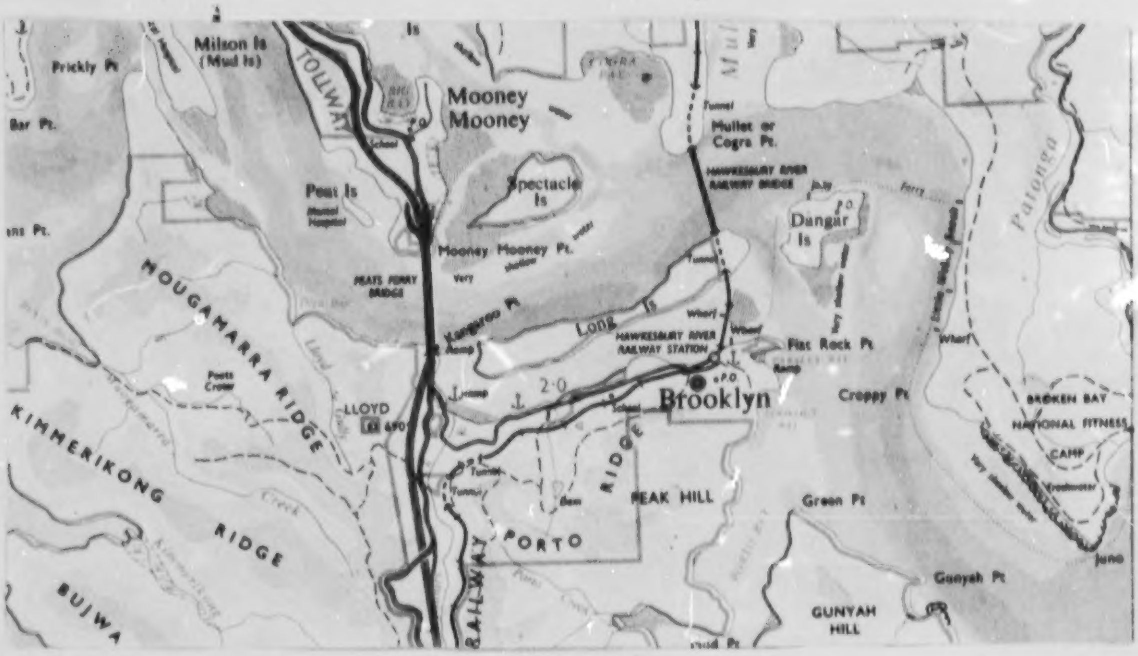
(A)



(B)


Golf Course
Substation
Creek
Caravan Park
Landing Ground
Spanish
Avenue
Rubbish Tip
Rifle Range
LOCKHART
Green Street
Oval
Cemetery
"Glenivy"
Haysheds
Racecourse and Showground
155
Burton Street
Brookong
"Killara"
HEADEN
"Pine Vale"
Napier Road
OAKLANDS-THE ROCK RAILWAY

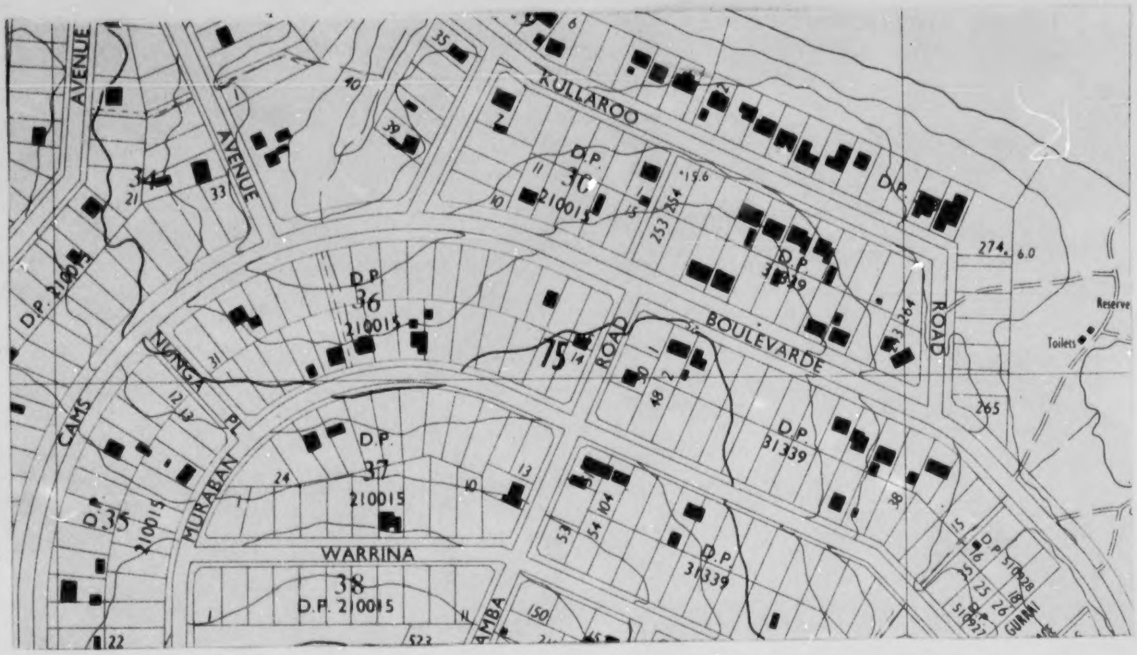
(C)


Milson Is
(Mud Is)
Prickly Pt
Bar Pt
TOLLWAY
Mooney
Mooney
Spectacle
Is
Peat Is
Mental
Hospital
Mooney Mooney Pt
PEATS FERRY
BRIDGE
Kangaroo Pt
Long Is
Mullet or
Cogra Pt
HAWKESBURY RIVER
RAILWAY BRIDGE
Dangar
Is
Wharf
HAWKESBURY RIVER
RAILWAY STATION
Flat Rock Pt
Brooklyn
P.O.
Croppy Pt
Patonga
BROKEN BAY
NATIONAL FITNESS
CAMP
MOUGAMARRA RIDGE
KIMMERIKONG
RIDGE
LLOYD
690
2·0
RIDGE
PEAK HILL
PORTO
RAILWAY
Tunnel
Green Pt
Gunyah Pt
GUNYAH
HILL
BUJWA
Juno

(D)

River
BATHURST

(E)


AVENUE
AVENUE
KULLAROO
D.P. 30 210015
D.P. 210015
D.P. 36 210015
D.P. 31339
BOULEVARDE
ROAD
ROAD
75
NUNGA PL
CAMS
MURABAN
D.P. 35 210015
D.P. 37 210015
WARRINA
38 D.P. 210015
AMBA
D.P. 31339
D.P. 510928
GURRAI
Reserve
Toilets
274
265

(F)

APPENDIX 10

CODE NUMBER /

ATTITUDES TO MAPS

This survey is designed to find out about your feelings towards maps.

1. Look at the FOUR maps.

2. Try this practice exercise.

   Answer the question by putting a tick along the line. This tick shows your feelings.

   A. I like the look of the maps because they are -

COLOURED				BLACK-AND-WHITE
Strongly prefer colour	Slightly prefer colour	Do not know	Slightly prefer black-and-white	Strongly prefer black-and-white

   For example, if you ticked near the word "COLOURED" you strongly prefer "COLOURED" as your answer.

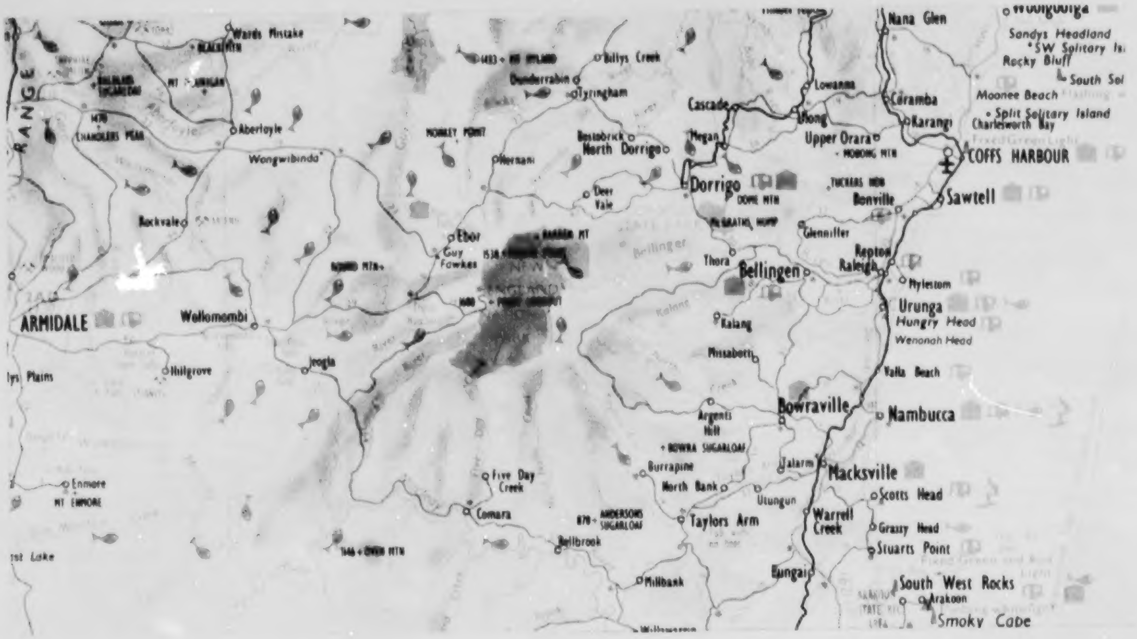
COLOURED				BLACK-AND-WHITE
✓				

3. Now answer the test questions.

Thank you.

R. GERBER

(A)

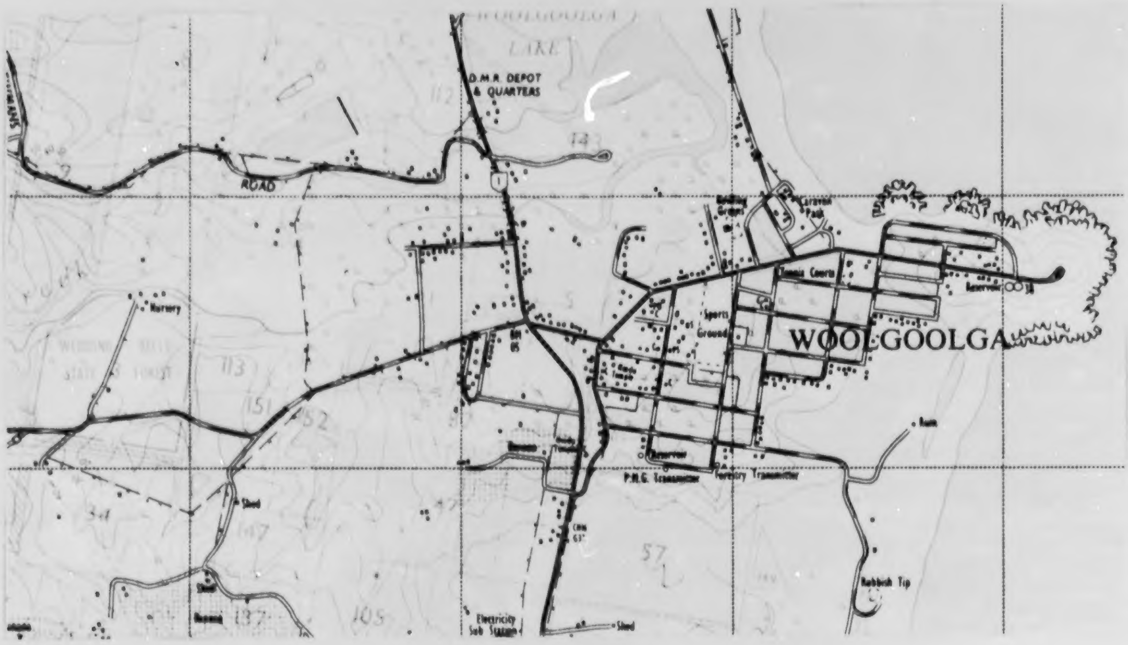


RANGE
Wards Mistake
Billys Creek
Dundurrabin
Tyringham
Aberfoyle
Chandlers Peak
Wongwibinda
Hernani
Bostobrick
North Dorrigo
Deer Vale
Rockvale
Ebor
Guy Fawkes
New England
ARMIDALE
Wollomombi
Jeogla
Hillgrove
Enmore
Mt Enmore
Five Day Creek
Comara
Bellbrook
Andersons Sugarloaf
Millbank
Cascade
Megan
Dorrigo
Dome Mtn
Lowanna
Ulong
Upper Orara
Nana Glen
Coramba
Karangi
Woolgoolga
Sandys Headland
SW Solitary Is
Rocky Bluff
South Sol
Moonee Beach
Split Solitary Island
Charlesworth Bay
COFFS HARBOUR
Sawtell
Bonville
Tuckers Nob
Glenniffer
Thora
Bellingen
Bellinger
Repton
Raleigh
Mylestom
Urunga
Hungry Head
Wenonah Head
Valla Beach
Kalang
Missabotti
Bowraville
Argents Hill
Bowra Sugarloaf
Nambucca
Burrapine
North Bank
Utungun
Taylors Arm
Macksville
Scotts Head
Warrell Creek
Grassy Head
Stuarts Point
Eungai
South West Rocks
Arakoon
Smoky Cape

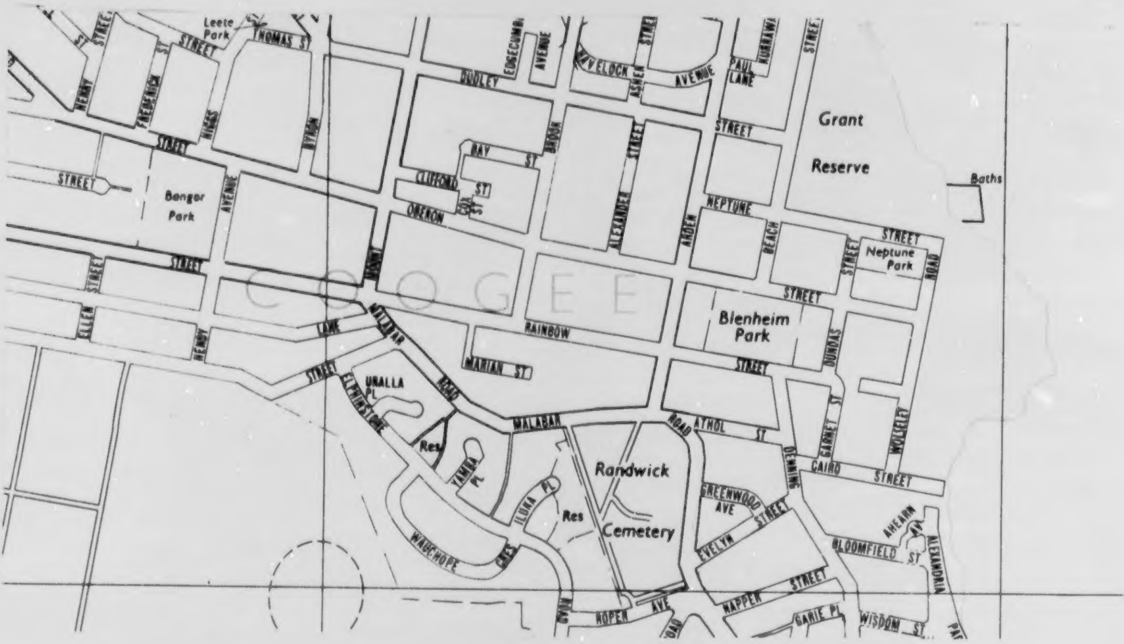
(B)

"Hazledene"
Quarry
37
300
300
300
300
240
780
Mahonga

(C)


WOOLGOOLGA LAKE
D.M.R. DEPOT & QUARTERS
112
143
ROAD
Nursery
WEDDING BELLS STATE FOREST
113
151
152
34
147
137
105
57
47
Sports Ground
Tennis Courts
Reservoir
WOOLGOOLGA
Baths
P.M.G. Transmitter
Forestry Transmitter
Rubbish Tip
Electricity Sub Station
Shed

(D)


Leete Park
THOMAS ST
HENRY STREET
FREDERICK STREET
HIGGS
BYRON
DUDLEY
EDGECUMBE AVENUE
HAVELOCK AVENUE
ASHER STREET
PAUL LANE
KURRAWA
Grant Reserve
Baths
Bangor Park
AVENUE
BAY ST
CLIFFORD ST
OBERON
BROOK
ALEXANDER STREET
ARDEN
NEPTUNE STREET
BEACH STREET
Neptune Park
ROAD
COOGEE
Blenheim Park
RAINBOW
MARIAN ST
ELLEN STREET
LANE
MALABAR ROAD
URALLA PL
ELPHINSTONE
Res
YAMBA PL
ILUKA PL
WAUCHOPE CRES
Randwick Cemetery
ATHOL ST
DUNDAS
GARNET ST
WOLSELEY
CAIRO STREET
DENNING
GREENWOOD AVE
EVELYN STREET
BLOOMFIELD ST
AHEARN
ALEXANDRIA
NAPPER STREET
HOPER AVE
GARIE PL
WISDOM ST

A. The objects marked on the maps are -

1. CROWDED — EMPTY

2. PLACED EVENLY — GROUPED IN A PART OF THE MAP

3. NOT ORGANISED — VERY ORGANISED

4. VARIETY OF INFORMATION — MONOTONOUS INFORMATION

B. The "look" of the maps is -

1. HARD — SOFT

2. ROUGH — SMOOTH

3. COARSE — FINE

4. SCATTERED — CLUSTERED

C. The colour on the maps is -

1. HOT — COLD

2. CLEAR — BLURRED

3. BRIGHT DULL

4. HIGHLY CONTRASTED LITTLE CONTRASTED

D. The accuracy of the information on the maps can be called -

1. GENERAL EXACT

2. INACCURATE ACCURATE

3. SIMPLIFIED SPECIFIC

4. VAGUE PRECISE

E. Your overall feelings toward these maps are that they are -

1. LIVELY DULL

2. CLEAR CONFUSING

3. PLANNED UNPLANNED

4. PREDICTABLE UNPREDICTABLE

APPENDIX 11

CODE NUMBER ☐ /

PREVIOUS EXPERIENCE WITH MAPS

This survey seeks answers about your past experiences with maps so that I can match these with your ability to understand and draw maps.

All of the questions can be answered by placing a tick in one of the boxes for each question.

So that your name does not appear on the form could you use the code number you will be given.

Also tick the relevant box - BOY ☐ GIRL ☐

Thank you for your help,

R. GERBER

(Tick one box for each question to answer these statements.)

A. 1. I am or have been a member of -

	YES	NO
(a) Boy Scouts or Cubs (Girl Guides or Brownies)	☐	☐
(b) Boys Brigade (Girls Brigade) or other church groups	☐	☐
(c) Bushwalking Club	☐	☐
(d) Orienteering Club	☐	☐
(e) YMCA Group	☐	☐

(f) What other groups do you belong to which move around in an area, e.g. trail bike clubs.

____

____

B. 2. I have done these things in my life -

	YES	NO
(a) flown in an aeroplane	☐	☐
(b) used a road map	☐	☐
(c) found my own way across a suburb or across town	☐	☐
(d) gone on a hike across country	☐	☐
(e) camped in the outdoors	☐	☐
(f) used a map to find my way	☐	☐

C. 3. In my school lessons I have -

	YES	NO
(a) never been told what a map is	☐	☐
(b) never drawn a map	☐	☐
(c) read off information from a map	☐	☐
(d) used maps to answer questions	☐	☐
(e) traced maps from books	☐	☐
(f) drawn maps freehand	☐	☐
(g) used my own scale to draw a map	☐	☐
(h) created my own set of signs to show things on a map (e.g. a square for a house)	☐	☐
(i) made a map of an area (e.g. my classroom)	☐	☐

APPENDIX 12

CODE NUMBER /

HOME ENVIRONMENT SURVEY

This survey seeks answers about your background so that I can match these with your ability to understand and draw maps.

All the questions can be answered by placing a tick in one of the boxes for each question.

So that your name does not appear on the form would you use the code number you will be given.

Also tick the relevant box. BOY ☐ GIRL ☐

Thank you for your help,

R. GERBER

(Tick one of the boxes to answer each question.)

			YES	NO
A.	(i)	1. Dad or mum belongs to a library.	☐	☐
		2. Mum reads to me.	☐	☐
		3. Dad reads to me.	☐	☐
	(ii)	4. I read books at home.	☐	☐
		5. I read books containing maps at home.	☐	☐
	(iii)	6. My family owns books containing maps.	☐	☐
		7. I borrow books from a library.	☐	☐
		8. I borrow books containing maps from a library.	☐	☐
		9. I read stories which contain maps in the newspapers.	☐	☐
		10. I read magazines which contain maps.	☐	☐

		YES	NO
B.	11. My parents play with me.	☐	☐
	12. The family goes places together or does things together at the weekend.	☐	☐
	13. Our family discusses things as a group.	☐	☐
	14. My parents are interested in my progress at school.	☐	☐
	15. At least one of my parents visits the school to find out what my school is like.	☐	☐
	16. At least one of my parents talks to my teacher(s) about my school work.	☐	☐

YES NO

17. I like to talk to visitors who come to my home. ☐ ☐

YES NO

C. 18. I watch television at home. ☐ ☐

19. It is a colour TV. ☐ ☐

20. About how many hours do you watch television each day? (Place a circle around the best answer.)

(a) none

(b) 1 - 2 hours

(c) 2 - 4 hours

(d) 5 hours or more

21. I watch television at school. ☐ ☐

22. I often look at maps at home. ☐ ☐

23. I play puzzles at home. (e.g. maze puzzles, jigsaws.) ☐ ☐

24. I play indoor games other than puzzles at home. (e.g. snakes and ladders.) ☐ ☐

25. I listen to the radio. ☐ ☐

D. 26. Describe the PRESENT or LAST job of your father. Be as exact as possible. (e.g. Dad drives his own truck.)

(Write your answer in the space below.)

27. Describe the PRESENT or LAST job of your mother. Be as exact as possible. (e.g. Mum is a secretary in a large office.)

(Write your answer in the space below.)

____

____

____

E. 28. Describe the suburb where you live by writing about the houses around yours. Describe their age, building materials, trees and gardens.

(Write your answer in the space below.)

____

____

____

____

____

____

29. Do you know your way around your suburb?

(e.g. Do you travel to your friend's place using your own directions or do you visit a relative following your directions?)

(Tick one of the boxes to answer this question.) YES ☐ NO ☐

30. How do you travel around your suburb most frequently?

(Place a circle around the best answer.)

(a) public transport

(b) car

(c) bicycle

(d) walk

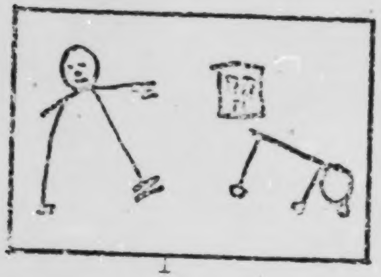
31. Do You live in a tall building (at least five storeys high)?

(Tick one of the boxes to answer this question.) YES ☐ NO ☐

APPENDIX 13 EISNER'S SCALE OF CHILDREN'S DRAWING ABILITY

Category 1	No horizon line present. Morphemes "floating", not standing on the edge of the paper.
Category 2	Morphemes standing on the bottom-edge of the paper. No horizon line drawn.
Category 3	Some morphemes standing on the bottom-edge of the paper, others floating in space.
Category 4	Morphemes standing on bottom edge of paper and horizon line drawn.
Category 5	Partial horizon line drawn.
Category 6	Two or more horizon lines drawn.
Category 7	Horizon line drawn. Morphemes floating above horizon line.
Category 8	Horizon line drawn. Morphemes standing on horizon line.
Category 9	Horizon line drawn. Some morphemes standing on horizon line, other morphemes floating above horizon line.
Category 10	Morphemes overlap ground but do not overlap horizon line.
Category 11	Morphemes standing on bottom edge of paper and overlapping horizon line.
Category 12	Horizon line drawn. Morphemes clearly overlapping horizon line.
Category 13	Horizon line drawn. Morphemes overlapping each other.
Category 14	Unclassifiable.

Visual Examples of Each Category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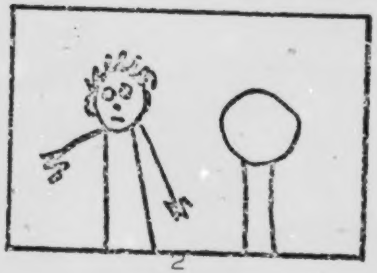
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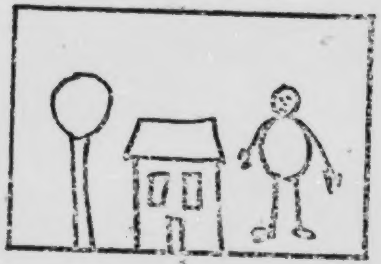
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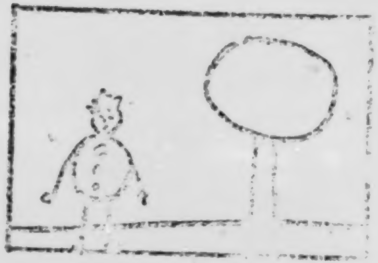
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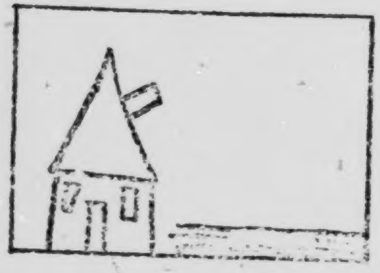
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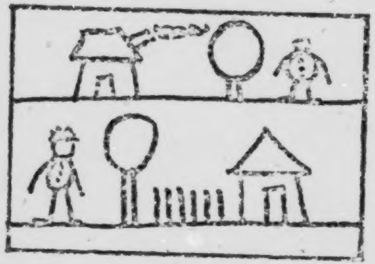
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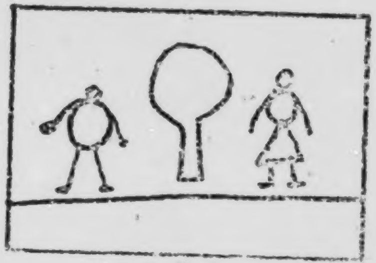
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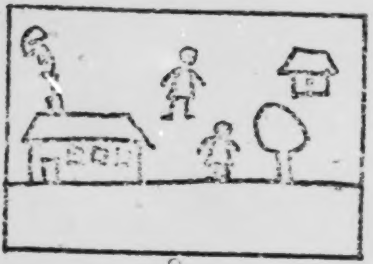
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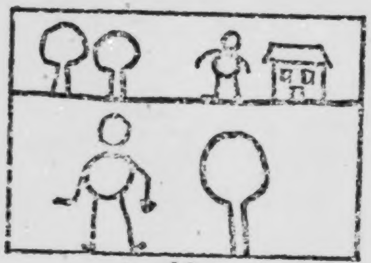
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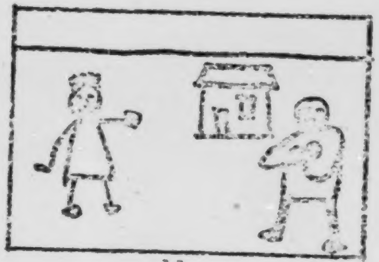
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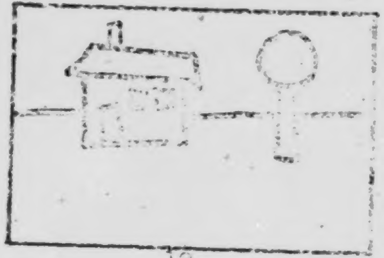
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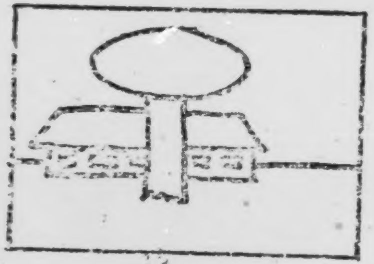
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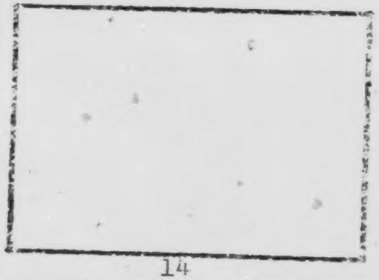

14

APPENDIX 14

CODE NUMBER | / |

MAP GENERALISATION

(pilot version)

This set of questions refers to TWO (2) SETS of maps.

Set 1 = Beenleigh A
Beenleigh B

Set 2 = Petrie 13
Caboolture - Sheet 38

These questions aim to find out how well you can understand maps at different scales and how the size of the map signs helps you read the maps.

Each question will refer you to parts of ONE of the maps. Refer only to that map to answer the question.

If you have any questions raise your hand and I will help you.

You may now answer the questions.

Thank you,

R. GERBER

A. Look at BEENLEIGH - Map A to answer these questions.

Write your answers in the blank spaces. If you cannot tell from the map place an "X" in the space for the answer.

1. TWO main RIVERS are (a) ______________________________ and

(b) ______________________________ . (2)

2. TWO key ROADS are (a) ______________________________ and

(b) ______________________________ . (2)

3. The HIGHEST LAND AROUND BEENLEIGH is ______________________________

______________________________ . It is ______________ metres high. (2)

4. The main SHOPPING AREA in BEENLEIGH is ______________________________

______________________________ . (1)

5. A SWAMPY AREA near BEENLEIGH is near ______________________________

______________________________ . (1)

6. BEENLEIGH'S SHOWGROUND is located in the ______________________________

______________________________ part of the town. (1)

7. Look at the lower half of the map. Which of these roads is less important?

Beaudesert Beenleigh Road ☐ Logan River Road ☐ I cannot tell ☐

(Tick one of the boxes to answer this question.)

8. Write brief answers to these statements.

(a) The ROAD signs on the map show the true road position and size.

____

____

____

(b) The black squares on the map show the true size and shape of the buildings.

____

____

____

B. Look at BEENLEIGH - Map B. You will be asked questions only about the area inside the heavy black line.

You may use the information in the margins of the map.

Write your answers in the blank spaces. If you cannot tell from the map place an "X" in the space for the answer.

1. TWO main RIVERS are (a) ______________________________ and (b) ____________________________. (2)

2. TWO key ROADS are (a) ______________________________ and (b) ____________________________. (2)

3. The HIGHEST LAND AROUND BEENLEIGH is ________________________ ______________________. It is __________ metres high. (2)

4. The main SHOPPING AREA in BEENLEIGH is ________________________ ______________________________. (1)

5. A SWAMPY AREA near BEENLEIGH is near ________________________ ______________________________. (1)

6. BEENLEIGH'S SHOWGROUND is located in the ____________________ __________________ part of the town. (1)

7. Look at the lower half of the enclosed area on the map. Which of these roads is less important? (Tick one of the boxes to answer this question.)

Beaudesert Beenleigh Road ☐ Logan River Road ☐ I cannot tell ☐

8. Write brief answers to these statements.

(a) The ROAD signs on the map show the true road position and size.

____

____

____

(b) The black squares on the map show the true size and shape of the buildings.

____

____

C. Look at the PETRIE map to answer these questions.

Write your answers in the blank spaces. If you cannot tell from the map place an "X" in the space for the answer.

1. The RIVER on the map is the ______________________. (1)

2. Petrie town is the meeting place of the ______________ Road (Highway) and the ______________ Railway. (2)

3. The ROAD crosses the RAILWAY. (Tick one of the boxes to answer this question.)

TRUE ☐ FALSE ☐ I CANNOT TELL ☐

4. In the top half of the map the highest land is ______________ ______________. It is ________ metres high. (2)

5. The area beside the Railway Station on the Petrie town side is used for ______________________________. (1)

6. PETRIE HOTEL is located ______________________________ ______________________. (1)

7. The buildings below the river on the map look like ______________ ______________________. (1)

8. How many bridges are there across the river? ______________ (1)

9. Write brief answers to these statements.

(a) The ROAD signs on the map show the true road position and size.

____

____

____

(b) The outlines of buildings on the map show their true size and shape.

____

____

____

D. Look at the CABOOLTURE map.

You will be asked questions only about the area inside the heavy black line.

You use the information in the margins of the map.

Write your answers in the blank spaces. If you cannot tell from the map place an "X" in the space for the answer.

1. The RIVER on the map is the ______________________________ . (1)

2. Petrie town is the meeting place of the ______________________ Road (Highway) and the __________________________ Railway. (2)

3. The ROAD crosses the RAILWAY. (Tick one of the boxes to answer this question.)

TRUE ☐ FALSE ☐ I CANNOT TELL ☐

4. In the top half of the map the highest land is ____________________ ____________________ . It is ____________ metres high. (2)

5. The area on the Petrie town side of the Railway Station is used for ____ . (1)

6. PETRIE HOTEL is located ______________________________________ ________________________________ . (1)

7. The buildings below the river on the map look like ________________ ________________________________ . (1)

8. How many bridges cross the river? ______________________ (1)

9. Write brief answers to these statements.

(a) The ROAD signs on the map show the true road position and size.

____

____

____

(b) The outlines of buildings on the map show their true size and shape.

____

____

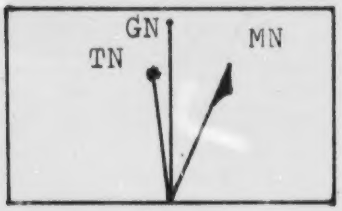
____

APPENDIX 15 MAP SIGNS TEST - PART ONE

ANSWER SHEET

Map A

A. (i)



(2 marks)

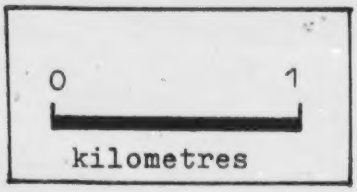
(ii) (a) The sign indicates the direction of north: MN indicates magnetic north, GN grid north, and TN indicates True North. (2 marks)

(b) Singleton Heights. (2 marks)

(c) North-east. (2 marks)

(d) Redbournberry. (2 marks)

B. (i)



(2 marks)

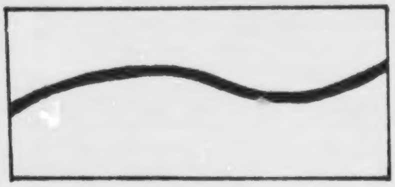
(ii) (a) The sign indicates the actual distance on the ground represented on the map. (2 marks)

(b) 2 kilometres (2 marks)

(c) 4 cm to 1 kilometre. (2 marks)

(d) 10 kilometres. (2 marks)

C. (i)



(2 marks)

(ii) (a) The winding line sign indicates the position and shape of a road on the map.

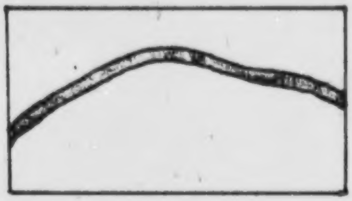
(2 marks)

(b) Redbournberry. (2 marks)

(c) It passes through Singleton and links Singleton with Singleton Heights. (2 marks)

(d) Singleton is located on flat ground. (2 marks)

D. (i)



(2 marks)

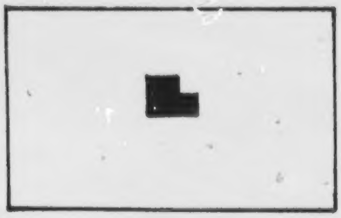
(ii) (a) The winding line sign indicates the position and shape of a river. It is a brownish colour. (2 marks)

(b) A long, narrow body of flowing water. (2 marks)

(c) Hunter River. (2 marks)

(d) Redbournberry to Scott's Flat. (2 marks)

E. (i)



(2 marks)

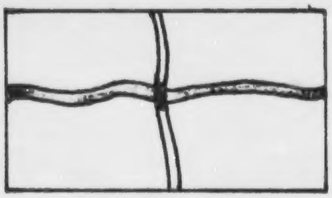
(ii) (a) The sign indicates the position and shape of the house. (2 marks)

(b) Scattered farm houses. (2 marks)

(c) Buildings for farming or industry. (2 marks)

(d) A small group of homes. (2 marks)

F. (i)



(2 marks)

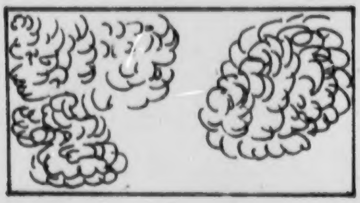
(ii) (a) The sign indicates the position and size of the bridge over the Hunter River. (2 marks)

(b) No. 3. (2 marks)

(c) Small river valley. (2 marks)

(d) There is more farmland near bridge No. 5.
(2 marks)

G. (i)



(2 marks)

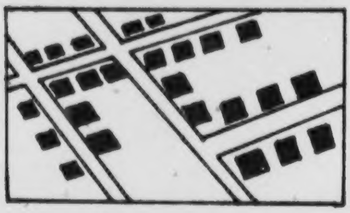
(ii) (a) The sign indicates the extent of the forest, the density of trees and their exact location.
(2 marks)

(b) Dangars Creek. (2 marks)

(c) There are many trees growing close together.
(2 marks)

(d) This is the place where the trees get most moisture. (2 marks)

H. (i)



(2 marks)

(ii) (a) The sign indicates the pattern of buildings and streets. The exact location of each building is visible. (2 marks)

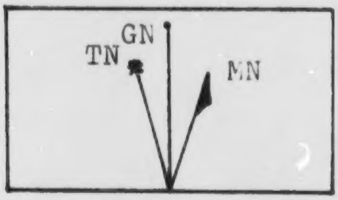
(b) Singleton Heights. (2 marks)

(c) Buildings which are used for houses, shops, schools and hospitals. (2 marks)

(d) Singleton has more large shops. (2 marks)

MAP B

A. (i)



(2 marks)

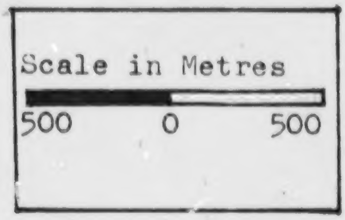
(ii) (a) The sign indicates the direction of north: MN indicates magnetic north, GN grid north, and TN indicates True North. (2 marks)

(b) Singleton Heights. (2 marks)

(c) North-east. (2 marks)

(d) Redbournberry. (2 marks)

B. (i)



(2 marks)

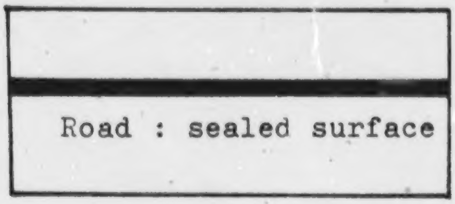
(ii) (a) The sign indicates the actual distance on the ground represented on the map. (2 marks)

(b) 2 kilometres. (2 marks)

(c) 4 cm to 1 kilometres. (2 marks)

(d) 10 kilometres. (2 marks)

C. (i)



(2 marks)

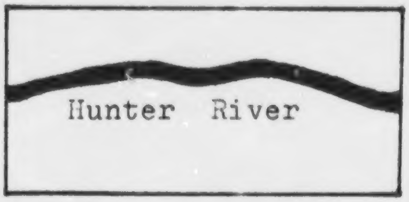
(ii) (a) The line sign indicates the position and general shape of a road on the map. (2 marks)

(b) Redbournberry. (2 marks)

(c) It passes through Singleton and links Singleton with Singleton Heights. (2 marks)

(d) Singleton is located on flat ground. (2 marks)

D. (i)



(2 marks)

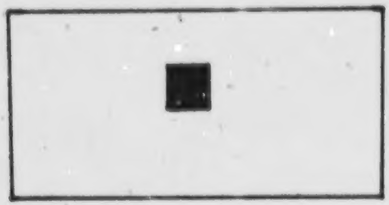
(ii) (a) The winding line sign indicates the position and shape of a river. It is coloured blue. (2 marks)

(b) A long, narrow body of flowing water. (2 marks)

(c) Hunter River. (2 marks)

(d) Redbournberry to Scott's Flat. (2 marks)

E. (i)



(2 marks)

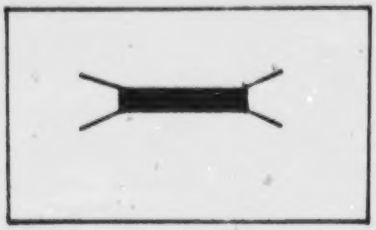
(ii) (a) This black square indicates the location of a house on a map. (2 marks)

(b) Scattered farm houses. (2 marks)

(c) Buildings for farming or industry. (2 marks)

(d) A small group of homes. (2 marks)

F. (i)



(2 marks)

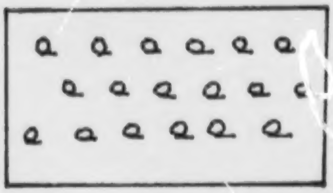
(ii) (a) This sign indicates the position of a bridge on a mapped area. (2 marks)

(b) No. 3. (2 marks)

(c) Small river valley. (2 marks)

(d) There is more farmland near bridge No. 5. (2 marks)

G. (i)



(2 marks)

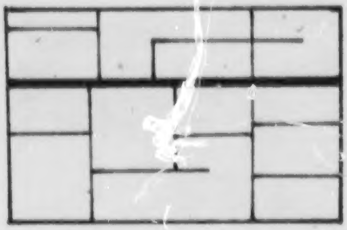
(ii) (a) The sign indicates the extent and density of trees. (2 marks)

(b) Dangars Creek. (2 marks)

(c) There are many trees growing close together. (2 marks)

(d) This is the place where the trees get most moisture. (2 marks)

H. (i)



(2 marks)

(ii) (a) The sign indicates the extent of an urban area. (2 marks)

(b) Singleton Heights. (2 marks)

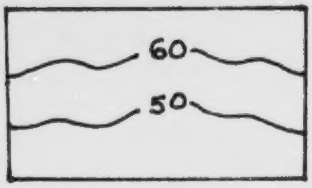
(c) Buildings which are used for houses, shops, schools and hospitals. (2 marks)

(d) Singleton has more large shops. (2 marks)

APPENDIX 16 QUANTITATIVE MAP SIGNS

ANSWER SHEET

A. (i)



(2 marks)

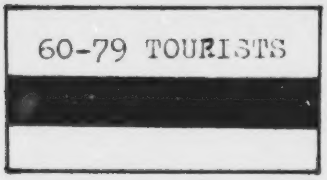
(ii) (a) It shows the height of land above sea level. All points on a contour line are at the same elevation. (2 marks)

(b) Reservoir Hill. (2 marks)

(c) The brown lines are close together. (2 marks)

(d) Whittingham. (2 marks)

B. (i)



(2 marks)

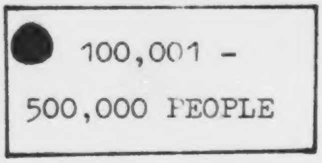
(ii) (a) It indicates how many tourists are moving among the island towns; the thicker the line the more tourists. (2 marks)

(b) Lang and Vale. (2 marks)

(c) The lines between both sets of places are of similar thickness. (2 marks)

(d) Lang. (2 marks)

C. (i)



(2 marks)

(ii) (a) The circles indicate the number of people in each city; the larger the circle the more people live in the city. (2 marks)

(b) Canberra. (2 marks)

(c) The circles showing their population are the same size. (2 marks)

(d) Near the coast from Brisbane to Adelaide. (2 marks)

D. (i)

▬

5000 BICYCLES

(2 marks)

(ii) (a) The bars indicate the number of bicycles in each town; the longer the bar the more bicycles in the town. (2 marks)

(b) Score. (2 marks)

(c) The bars beneath their names are of similar length. (2 marks)

(d) Hull. (2 marks)

E. (i)

▬

100 - 150 PEOPLE PER KM^2

(2 marks)

(ii) (a) The shadings indicate the population density; the heavier the shading the higher the population density. (2 marks)

(b) Tima. (2 marks)

(c) More people per square kilometre live around Mova. (2 marks)

(d) Coco. (2 marks)

F. (i)

░

0 - 500 METRES

(2 marks)

(ii) (a) The sign indicates the general elevation of the land; the darker the colour the higher the elevation. (2 marks)

(b) Haber. (2 marks)

(c) Flat land with low hills. (2 marks)

(d) Garon. (2 marks)

APPENDIX 17 COLOUR ON MAP SIGNS

ANSWER SHEET

A.

5. I cannot tell. (1 mark)
6. Yes. (1 mark)
7. I cannot tell. (1 mark)
8. Yes. (1 mark)
9. No. (1 mark)
10. Yes. (1 mark)

B.

5. Randwick Lodge. (1 mark)
6. Wattle Ponds Creek. (1 mark)
7. Dangars Creek. (1 mark)
8. Road Y. (1 mark)

APPENDIX 18 MAP GENERALISATION

ANSWER SHEET

A. 1. (a) Logan River; (b) Albert River. (2 marks)

2. (a) Pacific Highway/ Beenleigh- Redland Bay Road;
   (b) Beenleigh - Beaudesert Road/Logan River Road. (2 marks)

3. Mt. Warren; 107 metres. (2 marks)

4. Swamps are located near Holmview or Eagleby Sewage Treatment Plant. (1 mark)

5. The showground is located in the southern part of the town. (1 mark)

6. Logan River Road. (1 mark)

B. 1. (a) Logan River; (b) Albert River. (2 marks)

2. (a) Pacific Highway/ Beenleigh - Redland Bay Road;
   (b) Beenleigh - Beaudesert Road/Logan River Road. (2 marks)

3. Mt. Warren; 100-119 metres. (2 marks)

4. Eagleby Sewage Treatment Plant. (1 mark)

5. I cannot tell. (1 mark)

6. I cannot tell. (1 mark)

C. 1. North Pine River. (1 mark)

2. Redcliffe Road; North Coast Railway. (2marks)

3. True. (1 mark)

4. Car Park. (1 mark)

5. Intersection of Gympie Road and Redcliffe Road. (1mark)

6. Homes. (1 mark)

8. 2 (1 mark)

D. 1. North Pine River. (1 mark)

2. Bruce Highway; North Coast Railway. (2 marks)

3. True. (1 mark)

4. I cannot tell. (1 mark)

5. I cannot tell. (1 mark)

6. Homes. (1 mark)

7. 2 (1 mark)

APPENDIX 19 MAP LETTERING

ANSWER SHEET

A. Island Y

1. Kingsville. (1 mark)
2. (a) Marze; (b) Sting; (c) Megalong Rivers.(3marks)
3. Mt. Mee; 2534 metres. (2 marks)
4. Queensland Range. (1 mark)
5. Lycon and Blaxland. (2 marks)
6. Lycon and Jamison. (2 marks)
7. The Valley. (1 mark)
8. Toomba - Lycon - Urella. (1 mark)
9. Bamga. (1 mark)
10. Sting River. (1 mark)

B Island X

1. Duchessville. (1 mark)
2. (a) Albert, (b) Scott, (c) Malay Rivers. (3 marks)
3. Mt. Burra; 5218 metres. (2 marks)
4. King Range. (1 mark)
5. Beyer, Bell, Old or Wilkinson. (2 marks)
6. Bell and Charles. (2 marks)
7. Gordon Plains. (1 mark)
8. Tony to Bell. (1 mark)
9. Johnson. (1 mark)
10. Albert River. (1 mark)

APPENDIX 20 CONCEPT OF A MAP

ANSWER SHEET

1. A map is the representation drawn to scale from an orthogonal view on a flat surface of the features of part or all of the earth's surface. (2 marks)

2. B, C, E and F. (4 marks)

3. (i) Map B contains contour lines and a range of signs which represent the features around Lockhart.

   (ii) Map C is a layer-coloured tourist map of the Brooklyn area.

   (iii) Map E is a map locating streets, buildings and allotments. It contains contour lines.

   (iv) Map F is an orthophotomap of the Toronto area. Contour lines are superimposed on it. (4 marks)

APPENDIX 21 CHILDREN'S DEFINITIONS OF A MAP BY CONCRETE MAP-REASONING BLOCKS

Block 1

Map as a Picture.

1. A map is a pictor of places.
2. A map is a puchira of a diergrame on where to go.
3. A map is a picture showing a map of the wold.
4. A map is a picher of a place which is made to look smaller.

Map as a Reference.

1. A map is like a sheet of paper. It can help you find your way. Or it can help you get to other places so you won't get lost.
2. A map is something you find places on.
3. A map is a diagram of a state, town, etc. that helps you find your way around.
4. It tells you where to go.
5. A map shows you were to go and were you are.
6. A thing that tells you were to go.
7. A map is a piece of paper with directions on it that tells you where to go.
8. It is something that helps you find your way through a town or country.
9. I think a map is somethink that helps you when you are lost.
10. A map is a thing that shows you where you are.

Map as a Location of Places.

1. A thing that shows places and diagrams. And shows where something is located.
2. An area showing - , use, what is in it, e.g. bridges, creeks and other things.

3. A map is a piece of paper showing where thing and places are and streets and maps help you get from one place to another.
4. A map is a piese of paper wich has place on it.
5. A map is something that shose you roads and cities.
6. A map is a sheet of paper that shows you places.
7. A map is a piece of paper that shows where a place is or railroads, parks, rivers, islands, courses, schools, town, streets and other things.
8. A map tells you where towns, places and citys are.

Map as a Representation.

1. A map is a photograph or a drawing of a part of the world or made up and it shows you where the places are.
2. A map is an atlas.
3. A map is an area on a piece of paper or cardboard that shows main streets, rivers or where houses, schools or shops are.

Block 2

Map as a Picture.

1. A map is a picture - something showing roads, houses rivers etc.
2. A map is a picture or a drawing of an area.

Map as a Reference.

1. A map is something to help you find your way to something or somewhere.
2. It is a thing for when you are lost or want to know where to go, it will direct you places.
3. A map is a paper that helps you get to places.
4. A map is a booklet and inside is like you want to go from here to there a map shows you the way to go.
5. A map is something which shows you where to go,

what shop and other things. Maps are usually of countries, cities, towns, islands. streets, states.

6. A thing that shows how to get to places or where places are.
7. A picture showing areas and directions of a place.
8. A map is a street direter. It shows you how you get from place to place.
9. A map is to find out where places are.
10. I think a map shows names of streets, roads and shows you where to go.

Map as a Location of Places.

1. A piece of paper showing the whereabouts of a town, a piece of paper showing height and construction of a map.
2. A map is a thing that shows you a place.
3. A map is an area showing the streets, creeks, river, towns, houses.
4. A map is a piece of paper showing where a road is or places are.
5. A map is a piece of paper with roads and towns and rivers with their name on.
6. A map is a piece of paper showing islands, streets, oceans, mountains, rivers, suburbs. countries, etc.
7. A map is a piece of paper which has roads and rivers, forests.
8. A map is like a tiny atlas showing places,schools, citys, rubbish dumps and other things.
9. A map is a sheet of paper to show you where places are.
10. A map is a page that has a lot of streets and roads on it.

Map as a Representation.

1. A map is a diagram of streets, schools and area of a city.
2. A map is a picture of landforms and cities but not a photograph.
3. A map is a large or small area which details the land uses.
4. A map is the exact plan of the place of where it refers to.
5. A map shows you an outline of an area and marks to show where things are, and names things.
6. A map is a sheet of paper with places drawn to scale.
7. A map is an illustration of an area reduced to fit on the paper.

Block 3

Map as a Picture.

Nil.

Map as a Reference.

1. A map is to show you how to get to a place.
2. A map is something wich tells you where places are and if your lost the map can tell you the way.
3. A map is a drawing desined to let you find your way around your suburb, town or city.
4. A map is a thing that tells you the way to a place.
5. A map is a thing that you can look on and find out where a place is, how far away, etc.
6. A map is something that shows you a way or a place or anything about land.
7. It is a piece of paper which has direction to show you where to go.
8. I think a map is a piece of paper that shows you how to go from place to place.

Map as a Location of Places.

1. A map tells you where cities, streets and other places are. They sometimes tell you how to get to a place.
2. A map shows you where places are like the globe shows where all the countries are.
3. A map is where you find the location and direction of a place which is located of a street or map what ever sort of map you are using.
4. A map is anywhere that is marked clearly on a piece of paper with other names surrounding it so you can locate it.
5. It is a sheet of paper which tells you where to find different countries.
6. A map is a diagram which shows you the places of cities or the name of places and how to get there.
7. A map is a sheet that holds information on places and towns, animals and fruit.
8. A map is a paper that shows where everything is, e.g. countries, seas, roads.
9. A map is a thing to tell you where places are.
10. A map tells you where roads, railways, rivers, cities and towns are.

Map as a Representation.

1. A map is a picture of an area set out on a piece of paper, on a much smaller scale. It shows nearly every road and details, some show houses.
2. A map is a scaled down diagram of a specific town or state or of the world.
3. A map is an area drawn to scale on a piece of paper showing parks, streets, and shops, etc..
4. A drawing of a piece of land from a plan.
5. A map is a plan of something, e.g. a map of a town.

6. A map is a diagram to show a large place in a small amount of space and also shows directions to get from one place to another.

Block 4

Map as a Picture.

Nil.

Map as a Reference.

1. A map is a piece of paper or book showing how to get around an unknown place.
2. A map is a directory to help find your way.
3. It is a lot of lines and places to direct you to where you want to go.
4. A map is a thing that tells you where to go and how to get there.
5. A map is a direction to show where to go.
6. A map is a sheet of paper which shows where you must go to find a place you want to go to.

Map as a Location of Places.

1. A map is a plan of a place showing its position and other facts like industry and farming but not showing its size.
2. A map is a place on a piece of paper that shows you where places are or places that you are looking for.
3. A map is a drawing on paper which indicates contours, roads, railways, showgrounds, reservoirs etc. with different signs standing for different things, or shows land forms etc..
4. A map is a piece of paper that shows the geography of a place.
5. A sketch of the one area showing the main features.
6. A material with information that shows where various

things are situated. They aid people in finding these things which are marked on the map. They can be shaded or marked on in names and/or symbols.

7. A map shows the positioning of places in the world.
8. A map is a piece of information telling where you can find a place or thing easily.
9. A map is an areal view or picture of land showing various things about it, e.g. population, land use, elevation, rainfall.
10. A map shows us places, roads, churches etc. showing us where something is. It is scaled down to make it easier to read. It gives us directions and locations.

Map as a Representation.

1. A diagram of any area of land and water scaled down to fit on a piece of paper.
2. A map is a plan of an area of land, with or without anything on it that shows you a specific area on a smaller scale.
3. A map is a plan of an area on a much smaller scale than in real life. It shows many things including towns.
4. A map is a scaled-down drawing of a place.
5. A map is a given area of the world, describing its location on the globe and using contour lines to show the height of the land. Streets, bridges, lakes, etc., are land forms drawn on the map in the exact position as in true life, only using a scale to draw them smaller.
6. A map gives us an idea of a big area drawn down to scale.
7. A scaled down view of the aerial plan of an area or place.
8. A map is something that shows in detail what the area

looks like on a scaled drawing.

9. A piece of paper on which an area of land or sea is placed to scale.

10. A map is a representation of the earth or a portion of it on a plane surface.

APPENDIX 22 CHILDREN'S REASONS FOR PREFERRING COLOURED OR BLACK-AND-WHITE ORTHOPHOTOMAP AND TOPOGRAPHIC MAP.

A.

1. COLOURED ORTHOPHOTOMAP.

Block 1 a) Because the coloured map is brighter and easier to look at.

b) The coloured map is a lot easier to read because the writing stands out better.

c) Because the coloured one is more easier to read.

d) Because it looks more interesting.

e) Because the black-and-white map has black words which don't show up very well and it is hard to read.

f) Because the writing is black and the map is black and white.

g) Because the black and white picture has black writing and the picture is black.

Block 2 a) Because you can tell what is what by the different colours on the map and what they stand for.

b) It has different colours indicating rivers, roads, railways, etc. while the other doesn't.

c) It is easier to find things because it shows up better.

d) Because the black and white map is all grey and hard to read.

e) Because on the black and white map the places names are in black too, so it is hard to find the places.

f) Because the black letters stand out more on the coloured map than on the black and white one.

Block 3 a) I chose this map because you can see the different colours on the land - where the forests are thicker or thinner.

b) Because the contour lines are easier to read on it. Also the colour is more interesting.

c) Because you can see the vegetation coloured green and the rivers.

d) Because the black-and-white one is all dark and all the lines are dark.

e) I chose the coloured map because the black writing in the black and white doesn't stand out as much in the coloured **one.**

f) Because you can see the black writing clear against the colours.

Block 4 a) Using different colours was easier to see different parts and places on the map. It is easier to distinguish between different bits.

b) Because all the signs are different colours.

c) It is more realistic.

d) Because different colours represent different things on the map.

e) It is more distinct and clearer. It shows a better colour of the land.

f) The printing shows up against the colour.

2. BLACK-AND-WHITE ORTHOPHOTOMAP

Block 1 a) Because it is easier to just lock at it then get what you want.

b) Because I understand more than the coloured one.

c) I chose the black-and-white one because it is easier to read.

Block 2 a) Because it is clearer.

b) Because the colour is sharp in some places and the black and white one is evenly coloured.

c) I think it shows more on the black and white one.

Block 3 a) Because the colours confuse me.

b) It is easy to read because colour colours the name.

c) I chose it because I find it easier to read.

Block 4 a) Colours are all blotchy.

b) Because the black stands out from the white which makes it clearer. The greens seem to blend in with the other greens.

c) The coloured map isn't clear. You can't see anything.

B.

1. COLOURED TOPOGRAPHIC MAP.

Block 1 a) Because you can tell easier where the roads and rivers are.

b) Because the colours make me feel refreshed.

c) You can see the rivers better.

d) Because I can see how dense the forests are and what direction they are in.

e) Because it is bright.

Block 2 a) Because the colour is clearer and you can see the words easier.

b) Because when you glance at the map it looks more appealing.

c) Because it is easier to find places.

d) Coloured maps are bright not dull and they show the colour of the rivers.

Block 3 a) Because it is clearer to see land and water, and it's generally clearer.

b) Because you can find what a place is like by its colour. If blue you know it's water of some kind.

c) I chose the coloured map because you can see the rocks, towns and rivers better than the black-and-white one.

d) Because I like colour and it looks nicer.

e) Because the marks for trees are green and the rivers blue.

Block 4 a) Because things like the rivers, swamps and forests can be contrasted more clearly on the white surface.

b) Because on the coloured map you can tell what a place is by its colour.

c) Easier to read and clearer to understand the information it is conveying.

d) It shades things clear and separates different parts of vegetation.

e) I chose the map because it is much more easy to understand. It is more interesting to look at.

2. BLACK-AND-WHITE TOPOGRAPHIC MAP.

Block 1 a) Because it is black and white.

Block 2 Nil.

Block 3 Nil.

Block 4 a) It is less confusing than colour.

b) Because it is very clear because black stands out against the white.

APPENDIX 23 CHILDREN'S REASONS FOR PREFERRING COLOUR IN CARTOGRAPHIC SIGNS ON THE SINGLETON ORTHOPHOTOMAP OR TOPOGRAPHIC MAP.

A. ORTHOPHOTOMAP.

Block 1 a) Map A is more colourful.

b) It is easy to look straight at whatever you want.

c) Because they give you more details.

d) It is not as dark.

Block 2 a) It is easier to read.

b) Because it was easier to find things on Map A.

c) It is a photograph and you can easily tell.

d) Because it was easy to read the writing.

Block 3 a) Because map A has the colours for rivers, shrubs, etc.

b) Because you notice details more.

c) The signs are clear.

Block 4 a) Because it does not have lines going all over it, you can see every tree and house.

b) Because it is a photograph and you can actually see them.

c) Brighter colours and the signs are easier to read.

d) Crops are more distinct.

B. TOPOGRAPHIC MAP.

Block 1 a) Because it is not as dull you can find places better.

b) Because it has more names of places.

c) The colours of the map are easier to read.

d) Because it is not full of colour.

e) Because it is not smothered.

f) Map B shows you land, crops, houses and parks.

Block 2 a) It has different colours and a key.

b) Because the colours are brighter on B because they go from one extreme to the other.

c) Because it is much better marked.

d) Because the colour varies.

e) Map A is a photograph and is harder to read.

f) Because it is clearer and more spread out and does not have as many things.

Block 3 a) Because it has a white background.

b) Because it is clearer and doesn't have different colours every few centimetres.

c) Because the colours are brighter and the brighter colours help, e.g. rivers - blue.

d) It looks nicer and the colours are clearer and there are more variety of colours.

e) The roads and rivers are more clearer.

f) Because the names blend in with the colour on Map A.

Block 4 a) Map B uses different colours which stand out against each other while Map A used all green.

b) Because the colours are definite on Map B and each subject, e.g. roads, has a particular colour.

c) Because the symbols are shown more clearly and the colours contrast and so stand out.

d) Because the signs are different and stand out more on white. Map A is all the same colour (different shades).

e) There is a key at the bottom and you can tell what type of forests and roads there are.

f) Because the colours are distinctly different from each other.

APPENDIX 24 CHILDREN'S REASONS FOR PERCEPTION OF LACK OF DISTANCE BETWEEN SIGN AND REFERENT ON COLOURED ORTHOPHOTOMAP AND TOPOGRAPHIC MAP

A. COLOURED ORTHOPHOTOMAP

Block 1 a) It looks more real and has more detail.
b) Because it is a photograph and map B is only a drawing.
c) The colours are of real life.
d) The homes look real and the road looks real.
e) It is surrounded by green.
f) Because it is like the land.

Block 2 a) Because it is the colour of real life - scrub and crops.
b) Because you can see all of the houses and fields.
c) Because you can see the roads better.
d) Because map B is just like a drawing.
e) Because you can see the houses more clearly.
f) Because it is a real photograph.

Block 3 a) Because they are showing houses in their natural colour.
b) Because it is a photo and looks more realistic.
c) Because it has got more real colours in it.
d) Because you see if its trees or plains.
e) They are taken of a real landscape.
f) That is the colour they are.

Block 4 a) Because its a photograph of the land and that is the colour of the land.
b) Because it is a real photo and map B is only a sketch, e.g. there are no red roads or towns.
c) Map A is a realistic photo taken as an aerial

view.

d) It is a photograph-like map. The other one is a diagrammatic one.

e) Because in map B the colours go from green to white where as in map A they merge.

f) Because map A looks like a photo with the crops and everything.

B. COLOURED TOPOGRAPHIC MAP.

Block 1 a) Because it has more lively pictures.

b) It has got colour which makes you feel closer to live.

Block 2 a) Because map B isn't as coloured as map A.

b) The river is blue.

c) The colours are light and dark green.

d) on Map A the colours are dull and everything would not be dull like that.

Block 3 a) Because the river is blue.

b) There isn't too much colour on map B and it isn't squashed up.

Block 4 a) Because rivers are usually blue and forests are green, but on map A rivers are brown.

b) I chose B because on map A there is far too much colour, but if the colours weren't in so many shades of green I think I would like map A more.

c) Everything is much clearer.

d) They are the right colours.

APPENDIX 25 CHILDREN'S REASONS FOR PREFERRING TYPES OF ROAD SIGNS ON THE COLOURED ORTHOPHOTOMAP OR THE COLOURED TOPOGRAPHIC MAP.

A. COLOURED ORTHOPHOTOMAP.

Block 1 a) Because it shows clearly where the roads go and where they end.

b) Because it tells you what sort of road it is.

c) Because you can see it better.

d) Map A is more colourful.

Block 2 a) Because the roads are clearer.

Block 3 a) Because they show more of the shape of the road.

b) Because it is a photo and looks really real.

c) Because the roads are not just lines.

d) Because it looks more lively.

Block 4 a) Because you can see detail on them.

B. COLOURED TOPOGRAPHIC MAP.

Block 1 a) Because the red lines are thicker.

b) Because it is brighter.

c) It has red lines for roads.

d) Because it shows more detail.

e) It has a key to read.

Block 2 a) Because in map A the roads are the same colour as the rivers, while map B has different colours which are easier to recognise.

b) Because it shows the highways, main roads and dirt roads.

c) Because of the colours of the roads.

d) It has a special key for each road.

e) Because the roads are marked on more clearly.

Block 3 a) I chose this map because the roads are different colours - if its bitumen or a dirt road.

b) Because the key gives the conditions.

c) Because you can't tell the difference on map A since the roads look the same.

d) Because it gives you the type of map on the road.

Block 4 a) Because there is a key which tells you what type it is according to the colours of the roads marked in.

b) It is a drawing, the roads are more clearly defined and drawn in a brighter colour.

c) Because the roads are of different sizes and different colours.

d) Because the red stands out against the white. It shows the class of road, how important and if it is sealed.

e) Because the roads on map A are all the same colour.

f) Because it is a sketch and has different colours which don't smudge.

APPENDIX 26 CHILDREN'S REASONS ON THE LOCATION OF TREES ON THE COLOURED ORTHOPHOTOMAP AND THE COLOURED TOPOGRAPHIC MAP.

A. COLOURED ORTHOPHOTOMAP.

Block 1 a) Because you can see the trees.

b) Because it is a photograph and has to show the exact position of trees.

c) Because they look real and they are close together.

d) Because they look like real things.

Block 2 a) I chose it because the trees are easier to pick out.

b) Because the colour is like the colour of trees (real) same shape.

c) Because the trees are photographed.

d) Because it shows you a better position of the trees.

e) Because it is a photograph and would be more accurate.

Block 3 a) Because the colours show where the trees are.

b) Because you can see the actual trees.

c) Because it is a real photo and they look more like trees.

d) I chose this because it is a real picture not a drawing.

e) Because it is a photo and would be more accurate.

Block 4 a) Because it is a photograph, and in map B, the trees have just all been drawn on in a particular pattern to show the approximate areas where trees are.

b) I think map A since it is an aerial view placing the trees more exactly.

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c) Because map A is a photo and so shows the exact real position, whereas map B only puts symbols there to show that there are trees thereabouts.

d) Because a photograph gives you the actual place and a drawing only estimates places.

e) It is a true photograph showing the real positions.

B. COLOURED TOPOGRAPHIC MAP.

Block 1 a) Because it shows what colour they are where they are where as you can't see that on map A.

b) It has proper pine trees.

c) The trees are the real colour.

d) They have colours for trees.

e) Because it has more detail.

Block 2 a) The other map is just all brown and black.

b) Because map B shows you the exact colours.

c) Because the trees are coloured green with little marks on them.

d) It's clearer and shows the bumps.

Block 3 a) Every object is a different colour, so you can see the trees.

b) On map B there is green for trees and white for the rest, so it is easier to read and find exact positions.

c) Because it has been shown to scale more accurately.

d) Because the trees were marked out.

Block 4 a) It shows more clearly the dense forests and the not so dense forests.

b) It shows the trees scattered in the specific places in a different colour on the map.

c) Because the trees are a brighter green.

d) Because it is not crowded.

e) Because they don't show dots but show green shapes.

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